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Irmeli Vuorela: Pollen Analysis as a means of tracing settlement history in SW-Finland

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POLLEN ANALYSIS AS A MEANS OF TRACING SETTLEMENT HISTORY IN SW-FINLAND

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Abstract

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The incidence of human settlement, principally that based on agriculture, at five localities in south-western Finland in the parishes of Vihti, Huittinen, Vehmaa and Hattula over the last 3000 years is traced by means of relative and in part also absolute pollen analysis.

Indicators of agriculture are found in western Uusimaa and in South-West Finland almost continuously from the Bronze Age onwards. These pollen types, especially the Cerealia, increase markedly at a level which may be interpreted as corresponding to the first permanent field cultivation in the area, although local variations occur in the date of this event. Both the low level of settlement which prevailed in Uusimaa into the modern era and the early establishment of settlements in South-West Finland are reflected in the results. The spread of peasant culture into Häme beginning during the Roman Iron Age and the uninterrupted development of this culture since then are demonstrated from two lake profiles.

The results are matched against the history of these parishes as reflected in archaeological finds.

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I. INTRODUCTION

In spring 1972, the author received a comission from the Finnish Division of the Nordic Deserted-Farm Project to study the history of settlement in Southern and South-Western Finland by means of pollen analysis. The method involves the evaluation of the influence of cultural factors on the vegetation through the frequencies within the total pollen spectrum of those pollen grains which are considered to be "cultural indicators", in particular cereal pollen. The deciding factor in selecting the sites for investigation was naturally the presence of peat-bog or lake sediments in the relatively close proximity of a known area of prehistoric settlement.

The sites chosen for the present work (Fig. 1) were Kirkkojärvi at Kirkonkylä in the parish of Vehmaa, Loimansuo at Loimankylä in the parish of Huittinen, Katinhännänsuo at Salmi in the parish of Vihti, Lehijärvi at Ihalempi, in the parish of Hattula and Armijärvi at Nihattula in the same parish. The first two of these represent the county of Turku and Pori, Katinhännänsuo the county of Uusimaa and Lehijärvi and Armijärvi that of Häme. Although no established prehistoric dwelling site is found in the immediate vicinity of Katinhännänsuo, it may be included here to represent Uusimaa since a detailed analysis of the cultural indicators in its pollen spectra is already available.

Radiocarbon dates have been obtained for the profiles from these sites, enabling their cultural features to be related more exactly with

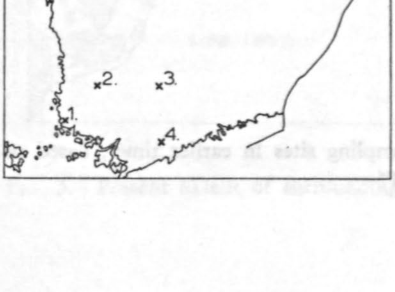


FIG. 1. Southern Finland, location of sites. 1. Kirkkojärvi, 2. Loimansuo, 3. Lehijärvi and Armijärvi, 4. Katinhännänsuo.

the settlement history of the areas. In addition to that previously published for Katinhännänsuo (Hel-253, VUORELA 1972), 12 dates have been provided by the Helsinki University Radiocarbon Dating Laboratory, 2 from Kirkkojärvi, 3 from Loimansuo, 1 from Lehijärvi, 3 from Armijärvi and 3 new ones from Katinhännänsuo. It is important from the point of view of the C^{14} method for the level which is dated to be accurately definable in terms of the features appearing in its pollen composition. Therefore an effort has been made to study each profile to an adequate depth, so that any regularity appearing in the pollen spectra for the Subatlantic period, i.e. the last 2500—3000 years, will become apparent. The minimum depth, where the profile permitted, was taken as being the rise of *Picea*, which in this area precedes the zone VIII/IX boundary (DONNER 1963, 1971), which in turn corresponds to the Bronze

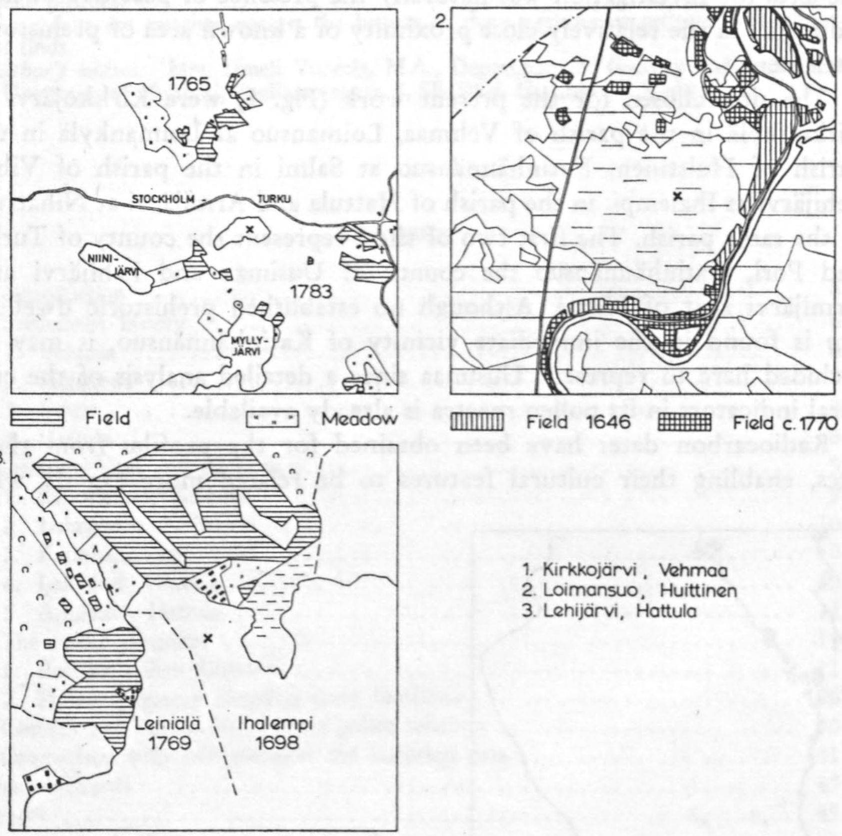


FIG. 2. Extent of field areas surrounding the sampling sites in earlier times, based on historical maps.

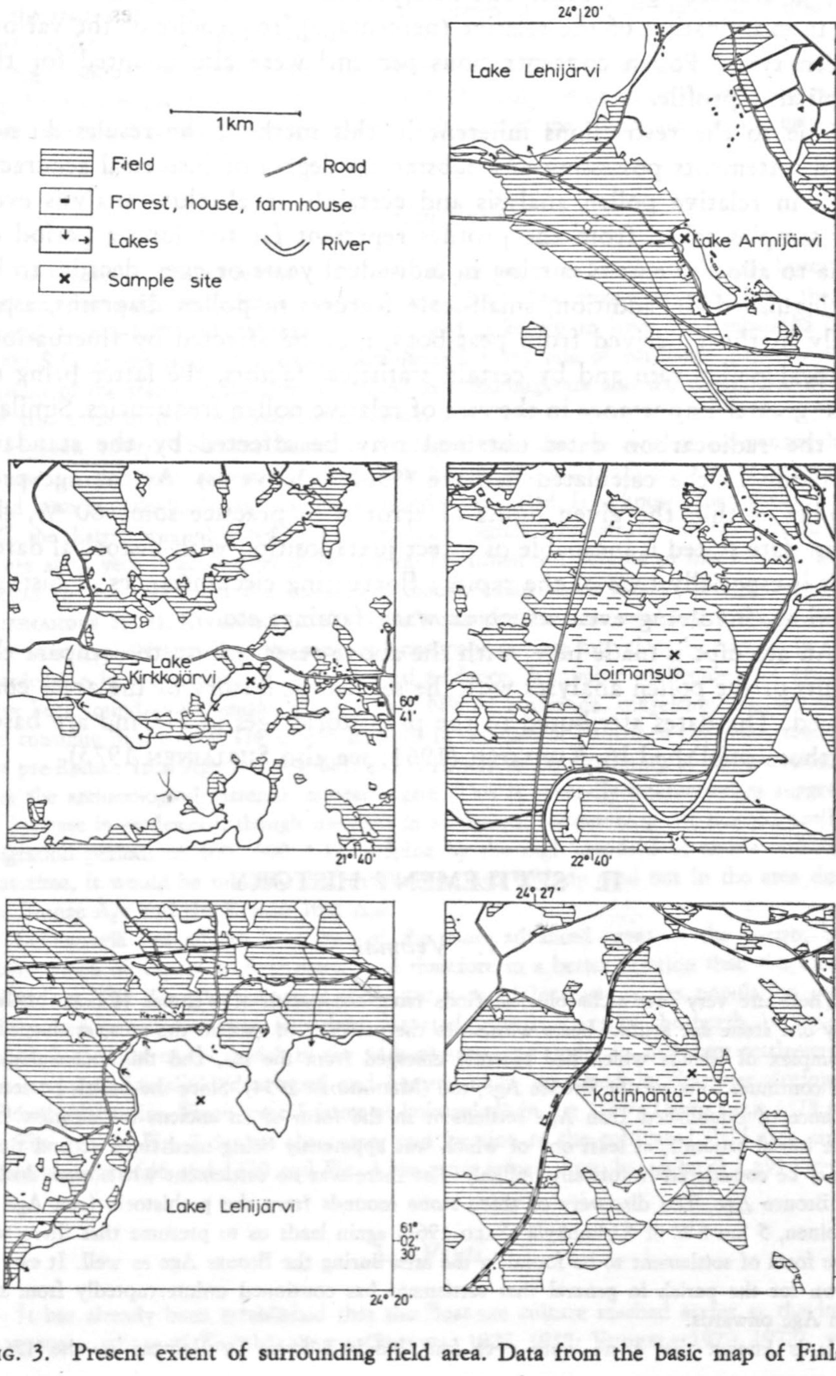


FIG. 3. Present extent of surrounding field area. Data from the basic map of Finland.

Age in archaeological time. The interpretation of the diagrams is based on an examination of the relative (percentage) frequencies of the various pollen types. Pollen concentrations per cm^3 were also counted for the Armijärvi profile.

Due to the restrictions inherent in this method, the results do not yield statements possessing any substantial degree of historical accuracy. Both in relative pollen analysis and certainly in absolute analysis even the samples taken from the profiles represent far too long a period of time to allow events occurring in individual years or even decades to be distinguished. In addition, small-scale features in pollen diagrams, especially in those derived from peat-bogs, may be affected by fluctuations in local pollen rain and by certain statistical factors, the latter being of even greater importance in the case of relative pollen frequencies. Similarly, the radiocarbon dates obtained may be affected by the standard deviation in the calculated half-life (5568 ± 30 years). As the age probability within the given limits of error is in practice some 60 %, the mean date stated is incapable of direct juxtaposition with historical dates. This is especially true of the rapidly fluctuating circumstances of historical time, involving events such as wars, famines etc.

An attempt is made here, with the above reservations, to compare the results of the pollen analyses with the settlement history of the areas concerned. The dates attributed to the prehistoric ages in Finland are based on those published by Kivikoski (1961; see also Siiriäinen 1973).

II. SETTLEMENT HISTORY

1. *Vehmaa*

There are very few archaeological finds from the parish of Vehmaa (Perälä 1951). Only one stone age artifact bears witness to the presence of man in the area, at that time a complex of islands which had recently emerged from the sea, and this archaeological void continues to cover the Bronze Age, too (Meinander 1954). Since the parish possesses evidence of established Iron Age settlement in the form of an ancient fortification and three burial grounds, at least one of which was apparently being used for a second time, it may be considered historically unlikely that there was no settlement whatsoever during the Bronze Age. The discovery of three stone mounds from the prehistoric Iron Age at Piiloinen, 5 km SW of Kirkonkylä (Salo 1968) again leads us to presume that there was some form of settlement to be found in the area during the Bronze Age as well. It can be shown for the parish in general that settlement has continued uninterruptedly from the Iron Age onwards.

It is known that there were over four hundred farms in Vehmaa in the 1560's

(JUTIKKALA 1973 a, b), and later in the 17th and 18th centuries the location of Kirkonkylä on the trade-route from Sweden through the present Uusikaupunki must have made its mark on settlement in the parish.

Fig. 2 shows the extent of cultivated fields around Kirkkojärvi in 1765 and 1783, and Fig. 3 the same, based on maps published in 1965. It should be noted that the oldest and most extensive cultivated areas are located to the east of the village, just off the map.

2. *Huittinen*

Loimansuo is situated in one of the most significant areas for the settlement history of Finland, the parish of Huittinen (LÄHTEENOJA 1949). The district emerged from the sea around 5,000—3,500 B.C. (VIRKKALA 1949) and is known to have been inhabited from 3,000 B.C. at the latest, the area of Loimankylä being one of particular importance on account of the status of the river Loimijoki as a thoroughfare and the general location of the area close to the confluence of Loimijoki and Kokemäenjoki, two major river routes (VALJAKKA 1949). Thus the banks of Loimijoki and the environs of Loimansuo have proved rich in Stone Age artefacts, the best known perhaps being the carved stone elk's head from Huittinen, dating from the Combed-ware period. It is known that around 1,800 B.C. the district was inhabited by an agricultural people representing the Boat-axe culture. There are a very large number of finds from Huittinen attributable to this culture, which spread to the area from the south-east, though again there are no Bronze Age finds (MEINANDER 1954). KIVIKOSKI (1967) doesn't consider that this need imply the disappearance of the inhabitants from the area, as a change in culture may alone be enough to cause a reduction in the amount of archaeological evidence. A number of Bronze Age artefacts have been found at Kokemäki, about 30 km NW of Huittinen, suggesting that settlement did continue in the area. The dearth of finds in the case of Huittinen continues even into the pre-Roman Iron Age (SALO 1968), and it is only at the beginning of the historical age that the archaeological material appears again. This is generally interpreted as suggesting an increase in settlement, though the peak in settlement indicators is not reached until the Migration periods of 400—800 A.D. Judging by the high standard of arable farming at that time, it would be unlikely that this culture had entirely died out in the area during the Bronze Age and the Roman Iron Age.

Loimankylä has always been one of the most advanced areas of the parish, being within reach of important river routes and therefore in a better position than the districts around it. The dawn of historical time saw a rapid increase in the population of the village and its surroundings. Huittinen, situated approx. 2 km to the north, became the population centre of the parish in the 14th century, and under its influence settlement on the banks of Loimijoki developed and became more organized in character during the following centuries. There were 5 farms at Loimankylä in the 1560's (JUTIKKALA 1973 a, b).

The map in Fig. 2 depicts the extent and location of the cultivated field area around Loimansuo in 1646 and 1770 and Fig. 3 the same information, based on the 1959 survey.

3. *Vihti*

It has already been established that the Boat-axe culture reached as far as the immediate surroundings of Katinhännänsuo (SOIKKELI 1929, 1932; VUORELA 1970, 1972).

Four Bronze Age villages practising agriculture are known to have existed in the neighbouring parish of Karjaa (af HÄLLSTRÖM 1948), though the only evidence of comparable settlement in Vihti dates from the pre-Roman Iron Age. Following the unrest of the Viking period, the 11th century, the people of Häme began to encroach further into Uusimaa, which had previously served them mainly as a hunting-ground (VOIONMAA 1947). The strategic position of Vihti beside the important waterway from the north through Hiidenvesi into Lohjanjärvi makes it probable that the people of Häme also occupied this area, and it is even considered likely that the present population of the parish originates from Häme (YLIKANGAS 1973), of which it formed a part administratively up until the 18th century (JUTIKKALA 1957).

The number of farms in the parish of Vihti in the 1560's is known to have been 157, i.e. only a third of the number in Vehmaa. The area remained until the early 19th century isolated from the advances in agriculture which affected Uusimaa generally, and slash and burn cultivation is known to have taken place even in the 1850's. By this time, however, the proximity of Helsinki had begun to affect the occupational structure of the area, leading to the development of handicrafts and commerce. Only in places was it thought necessary to increase the field area. The fluctuations in the size of the field area surrounding the sampling site are described in an earlier paper (VUORELA 1972).

4. *Hattula*

There are a large number of finds to suggest that the Combed-ware and Boat-axe cultures extended as far as the Hämeenlinna district (KIVIKOSKI 1961). The signs of settlement diminish in number after this, however, and remains from the Kiukais culture are scarce in the area. This lack of archaeological material continues throughout the Bronze Age and the pre-Roman Iron Age. Nevertheless, there are a few epineolithic ceramic finds to the east of Tampere, for instance (ÄYRÄPÄÄ 1953), which indicate that settlement was to be found in the interior of the country. Support has been increasing in recent years for the theory that settlement continued uninterruptedly throughout this period which is generally poor in archaeological finds. This possibility has been argued in both the archaeological (KIVIKOSKI 1955), and the historical (KERKKONEN 1971) and linguistic (ITKONEN 1972) literature. It is highly probable that the people whom we assume to have lived in the Hämeenlinna district during these centuries were still at the level of a primitive economy, with very few remains capable of preservation, especially since the raw materials of their hunting, fishing and primitive slash and burn cultivation would have been readily decomposable timber and bone. In the first few centuries A.D. field cultivation established itself in the area, spreading from the west. This culture has left behind it a range of artifacts which were in many cases accepted as the first indications of settlement in Häme.

The lake area, with the Hämeenlinna district as its head, was the centre of settlement throughout the Iron Age, and the surroundings of the lake Vanajavesi are rich in artifacts dating from the 6th and 7th centuries. It is significant that the Viking age, which entailed almost complete depopulation over the majority of Uusimaa, represents a considerable population increase and an extension of settlement in Häme. The numerous finds of Iron Age scythes and sickles are indicative of the importance of agriculture in Häme. Though during its expansion phase this agriculture was still chiefly of the slash and burn type, it is probable that by the later stages of the Iron Age, village settlements practising stable arable farming were to be found, especially in the centres. Cattle fodder was mostly gathered from natural meadows or open bogs, and to a lesser extent from deciduous trees. The gathering of this browse for the cattle is known to have continued into the 17th century.

The lake area of the southern tributaries of Kokemäenjoki retained its position as one of the major areas of settlement in Finland up until the end of the Middle Ages (JUTIKKALA 1933, LUUKKO 1957). The villages around Lehijärvi are known to have possessed a total of 52 farms in the 1560's (JUTIKKALA 1973b), and the field area under cultivation on the northern side of the lake during the 17th and 18th centuries was almost the same as today (Figs 2 and 3). The register of tithes for 1628 (Finnish State Archives, VA 4492: 74v—75v) gives figures for the field areas under cultivation in the villages bordering on Lehijärvi as follows: Sattula (SW of Lehijärvi) approx. 18 ha, Ihalempi approx. 17 ha, Leiniälä and Pelkola approx. 14 ha and Nihattula approx. 15 ha. This amounts to a considerable area of cultivation, though it must be borne in mind that due to the 2-year rotation system the annual sowings would only comprise about one half of this area.

In the 19th century farming in the area north of Lehijärvi was to a great extent bound up with other human activity in the area. Cultivation of the bogs increased in the 1860's and 1870's after the artificial lowering of the water level in Vanajavesi (AUER 1924, SAARNISTO 1971) which allowed vast areas of bog to be drained and used for farm-land (MALM 1903, E.F. SIMOLA 1903). A railway was built across the area in 1872.

III. SAMPLING SITES AND METHODS

1. *Kirkkojärvi, Vehmaa. Height 14.6 m a.s.l. (Fig. 3).*

The Lake is situated approx. 1 km west of Vehmaa Church, immediately adjacent to settlement. The field areas under cultivation around the lake are extremely small due to the poor soil and rugged relief of the area, and with the exception of its northern shore, it is surrounded by forest and bare outcrops of rock. The dominant tree species tends to vary with the soil condition.

The feature of principal importance for the occurrence of cultural indicators in the sediments is a brook which flows into the lake from the east, i.e. from the locality of the oldest part of the village. The importance of this brook is shown, for example, by the abundant *Typha* vegetation to be found on the eastern shore of Kirkkojärvi, a vegetation which in view of the barrenness of the shore must rely on additional nutrients carried in from elsewhere. The local settlement on the lake shore can scarcely be thought to affect the nutrient balance of the lake to any appreciable degree. Nevertheless, the fine material leached from the tiny cultivated plots should be borne in mind, and together with the general shallow nature of the shore this may have led to the occurrence of a belt of *Phragmites* on the northern side of the lake. Also the ancient road which runs to the north of the lake is a factor to be remembered when considering the passage of cultural indicator pollen into the Kirkkojärvi basin during the historical period.

The core was obtained using a Livingstone borer (LIVINGSTONE 1955), and sampled at 2 cm intervals between 0—20 cm, 2.5 cm intervals between 20—195 cm and 5 cm intervals between 195—225 cm. The ten lowermost samples were treated using both KOH and HF (Fægri & Iversen 1964), the remainder only with KOH. The samples were mounted in glycerine jelly, and counted to a basic figure of 500 AP.

2. *Loimansuo, Huittinen. Height 58.9 m a.s.l. (Fig. 3).*

The bog is located to the south of the main Forssa—Pori road, aprox. 50 km SE of Pori. It is a typical riverside bog which was created by the Kokemäenjoki spreading to flood the site of its former estuary at a time around 2,000—3,000 B.C. (Virkkala 1949). The district is characterized by broad, open farmlands and a long cultural history.

The local vegetation around the site is that typical of the raised bogs of south-western Finland. Species characteristic of the hollows on the bog are *Eriophorum vaginatum, Vaccinium oxycoccos* and *Sphagnum balticum,* and of the drier hummocks *Calluna vulgaris, Sphagnum fuscum* and stunted *Pinus silvestris.*

The base of the profile represents a level a short distance above the base of the bog. The upper 1.5 m of the core was taken with a Russian borer, and the lower part with a piston borer. It was sampled at 5 cm intervals throughout, and the preparations were made using the KOH method. A total of 1,000 pollen grains (AP+NAP) was counted for each sample.

3. *Katinhännänsuo, Vihti. Height 58.4 m a.s.l. (Fig. 3).*

The bog is situated in a very sparsely populated district. Alongside farming, the area has a peat industry which uses the major part of this bog as a source for its raw material. In the year in which the core was taken, 1967, only an area of just under 0.5 ha around the sampling site retained an undisturbed vegetation. This featured mainly stunted *Pinus silvestris* and a shrub layer of *Calluna vulgaris.* The topography and vegetation of the surrounding area is discussed elsewhere (Vuorela 1970, 1972, 1973), and the preparation technique is described in Vuorela 1970, 1972.

4. *Lehijärvi, Hattula. Height 80.7 m a.s.l. (Fig. 3).*

The site lies to the west of an esker chain running in a NW—SE direction and is approx. 10 km NW of the town of Hämeenlinna (Virkkala 1961). The village of Ihalempi and the Iron Age site at Kevola, both in the immediate vicinity of the lake, are indicative of early peasant settlement in the area. The location of the sampling site in a small bay surrounded by these areas of early cultivation (cf. Fig. 2) may be considered especially suitable for a study of the settlement history of the area by palynological methods. The general flatness of the area must also assist the transport of cultural indicator pollen towards the sampling site.

The present vegetation surrounding the bay and occupying the shallow belt near the lake shore suggests a high degree of eutrophication (cf. Järnefelt 1956). The following may be mentioned from a detailed species list (L.-K. Simola 1963): *Typha latifolia, T. angustifolia, Iris pseudacorus, Nymphaea candida* and *Stratiotes aloides.* These few examples serve as evidence of comparatively large amounts of nutrients being washed down from the surrounding ancient farming areas into the Lehijärvi basin. The present status of the lake may perhaps also be affected by the extensive peat layers beneath the water, whose nutrients may be dissolved in waters seeping through into the lake itself (Rindell 1903, L.-K. Simola 1963).

In view of the high mineral content of the sediments in this profile, it was necessary to limit sampling to deposits which proved younger than the lower parts of the two previous cores. The core was taken with a Livingstone borer and sampled at intervals of 1 cm between 0—15 cm and of 2.5 cm between 15—160 cm. The material was prepared using the KOH method alone for the section 0—45 cm, after which it proved necessary to use HF treatment as well.

5. *Armijärvi, Hattula. Height 87.9 m a.s.l. (Fig 3).*

The lake is situated SE of Lehijärvi and is separated from it by a strip of cultivated land about 1 km wide. Since settlement at the village of Nihattula which surrounds this lake is comparable in age with that at Ihalempi to the north of Lehijärvi, it is probable that cultural indicators originating in part from the same sources may be found in the sediments of these two adjacent basins.

Armijärvi lies immediately to the west of the esker chain mentioned above. Several springs rise in its bottom, preventing this small lake (200×700 m) from becoming eutrophic. The forest on its eastern shore, on the slope of the esker, is dominated by *Pinus*, but elsewhere the basin is ringed by deciduous trees, largely *Alnus glutinosa*.

The core from Armijärvi included those older deposits which were unobtainable from Lehijärvi. The core was taken with a Livingstone borer, and sampled at 10 cm intervals between 0—40 cm, and at 5 cm intervals between 40—50 cm, these deposits being composed of homogeneous gyttja, and at intervals of 2.5 cm elsewhere. The KOH method was used for the preparations, and the samples were mounted in glycerine jelly. The relative pollen counts were made to a basic total of 500 AP. For absolute counting (no. of grains/cm^3), *Lycopodium* tablets were added during preparation (Stockmarr 1971). The 500 AP grains counted then corresponded to 33—160 *Lycopodium* spores, from which figures the absolute pollen frequencies for the various species could be calculated. According to Stockmarr the standard error using this method would be 10 %.

IV. THE POLLEN DIAGRAMS

1. Relative pollen diagrams.

The K i r k k o j ä r v i core extends to a depth of 225 cm (Figs 4, 5), coming to an end in a layer of coarse sand. The lower portion, 185—225 cm, is composed of clay-gyttja, and represents the period when the lake was undergoing isolation from the sea (around 1,000 B.C.), while the

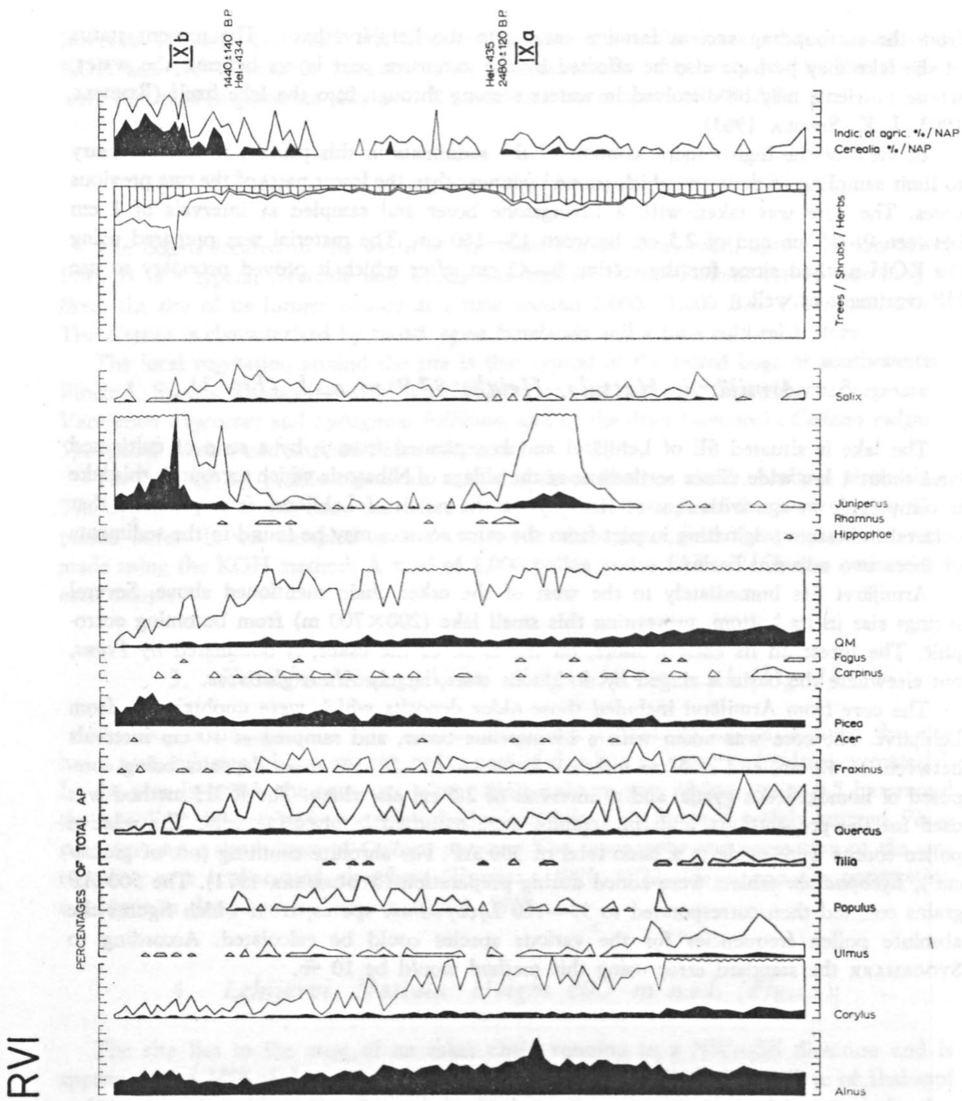


FIG. 4. Kirkkojärvi: Relative arboreal pollen diagram with radiocarbon dates.

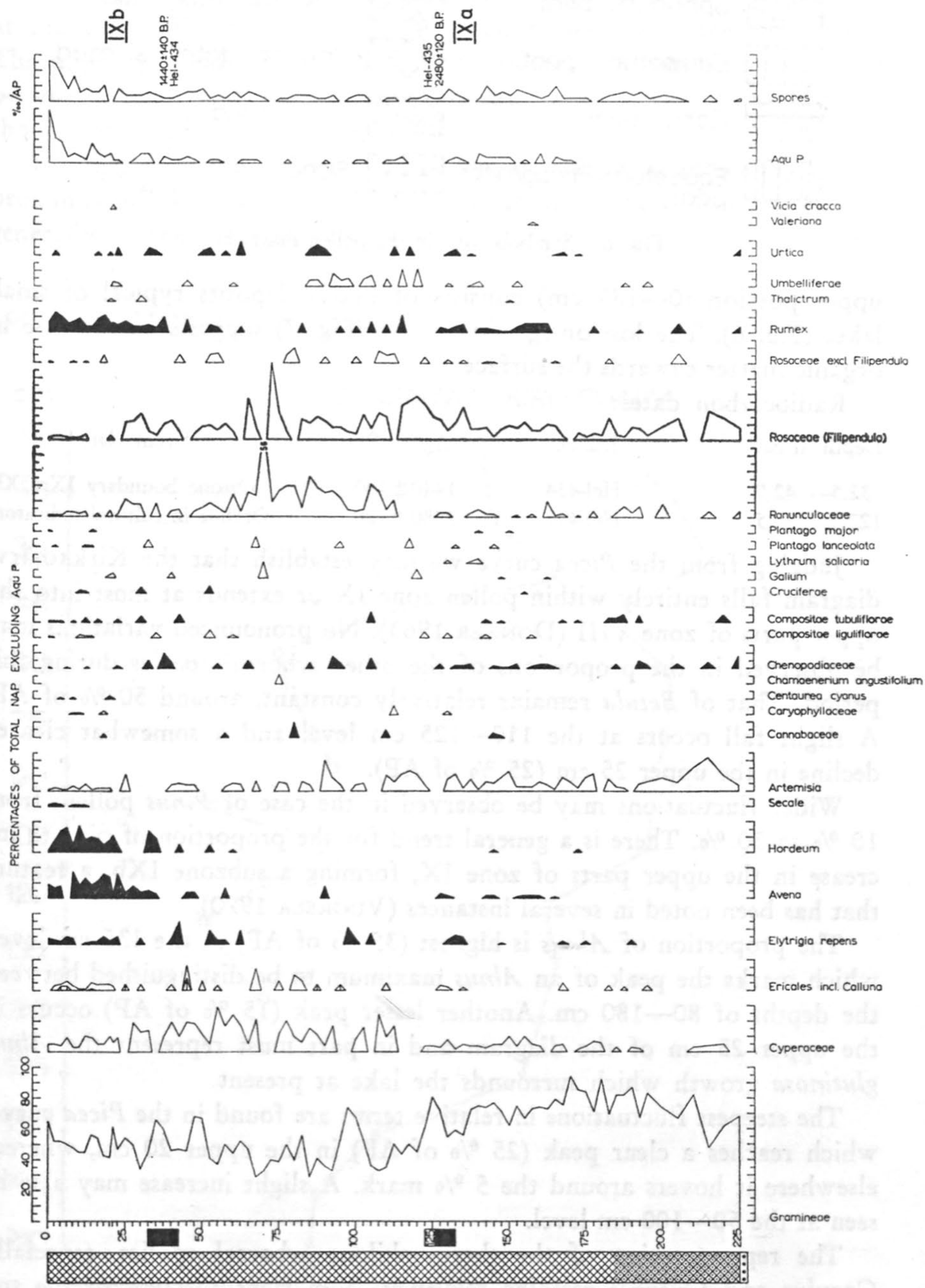


FIG. 5. Kirkkojärvi: Relative non-arboreal pollen diagram with radiocarbon dates. Agricultural indicators shaded.

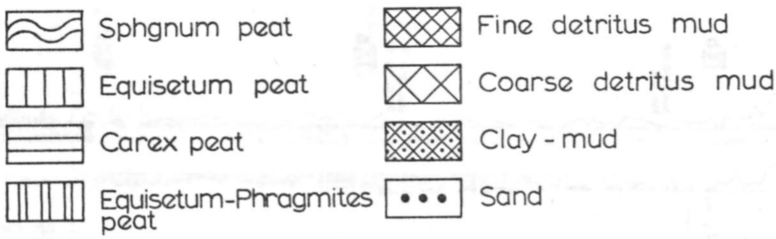


FIG. 6. Symbols used in the pollen diagrams.

upper portion (0—185 cm) consists of gyttja deposits typical of small lakes (Fig. 6). The loss-on-ignition curve (Fig. 7) suggests an increase in organic matter towards the surface.

Radiocarbon dates:

Depth in cm	Lab.no.	Age B.P.	Event dated
32.5— 42.5	Hel-434	1440±140	Subzone boundary IXa/IXb
122.5—132.5	Hel-435	2480±120	Decline in cultural indicators

Judging from the *Picea* curve we may establish that the Kirkkojärvi diagram falls entirely within pollen zone IX or extends at most into the upper parts of zone VIII (DONNER 1963). No pronounced variations may be observed in the proportions of the other arboreal species during this period. That of *Betula* remains relatively constant, around 50 % of AP. A slight fall occurs at the 110—125 cm level and a somewhat clearer decline in the upper 25 cm (25 % of AP).

Wider fluctuations may be observed in the case of *Pinus* pollen, from 10 % to 50 %. There is a general trend for the proportion of pine to increase in the upper parts of zone IX, forming a subzone IXb, a feature that has been noted in several instances (VUORELA 1970).

The proportion of *Alnus* is highest (35 % of AP) at the 135 cm level, which marks the peak of an *Alnus* maximum to be distinguished between the depths of 80—180 cm. Another lesser peak (15 % of AP) occurs in the upper 25 cm of the diagram and in part must represent the *Alnus glutinosa* growth which surrounds the lake at present.

The steepest fluctuations in relative terms are found in the *Picea* curve, which reaches a clear peak (25 % of AP) in the upper 20 cm, whereas elsewhere it hovers around the 5 % mark. A slight increase may also be seen at the 50—100 cm level.

The representation of the thermophilous arboreal species, especially *Corylus* and *Quercus* remains relatively high right through to the top of the diagram, though a decline in the Quercetum Mixtum curve is observable in the last 0.5 m.

Two very distinct *Juniperus* phases may be detected, the older located at the 125—155 cm level, and the younger comprising the last 50 cm. The opposite trend is found in the case of *Salix* which is at its highest between 50 cm and 125 cm, and increases once again below 150 cm, though restricted to a few percent.

The appearance of *Hippophae* pollen at 220 cm is indicative of the proximity of the sea, while *Rhamnus* is comparatively well represented generally in the diagram.

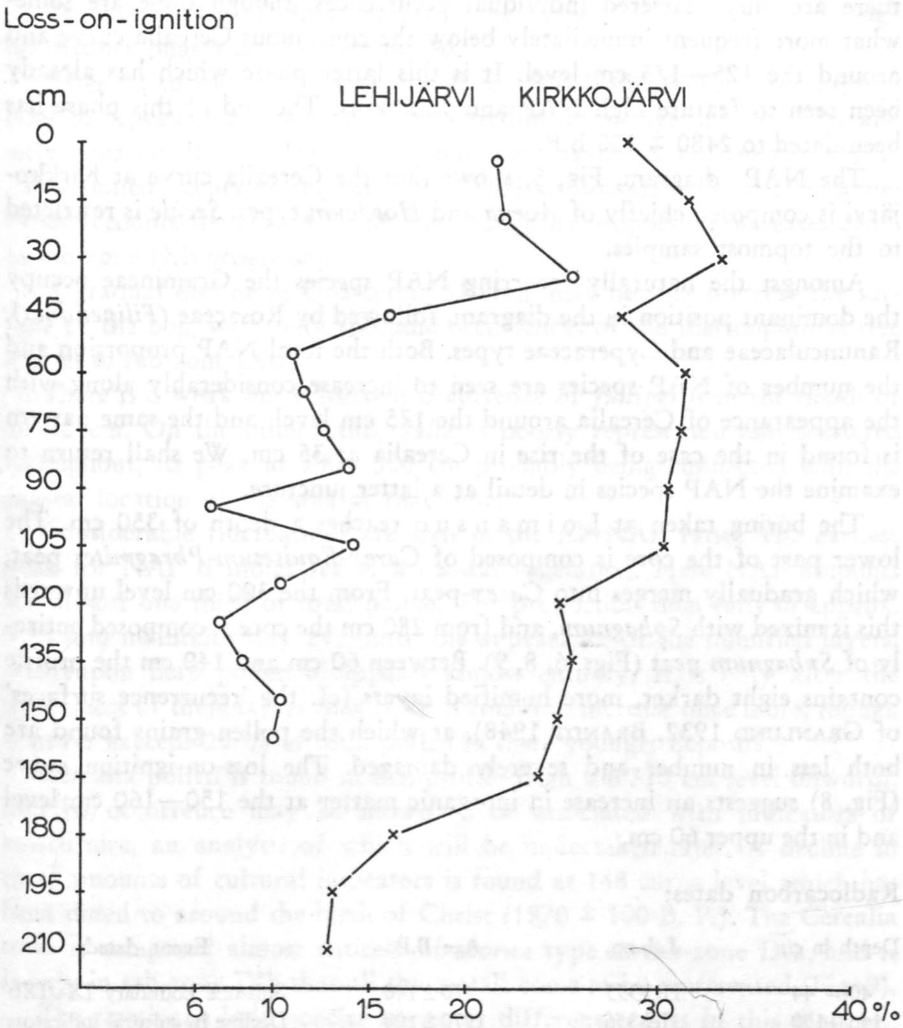


FIG. 7. Loss-on-ignition curves for Lehijärvi and Kirkkojärvi sediments.

An examination of the ratio of arboreal (AP) to non-arboreal (NAP) pollen shows two weak maxima for NAP, one at 125—175 cm, a peak of 15 %, and another in the uppermost part of the diagram, its proportion here increasing towards the surface and just reaching the 20 % mark in the topmost sample.

In order to facilitate interpretation a curve representing the ratio of Cerealia and 'cultural indicator' pollen types to total NAP has been added to the AP diagram. Continuous occurrence of Cerealia pollen is confined to the top 35 cm, from 1440 ± 140 B.P. onwards. Below this there are only scattered individual occurrences, though these are somewhat more frequent immediately below the continuous Cerealia curve and around the 125—175 cm level. It is this latter phase which has already been seen to feature high NAP and *Juniperus*. The end of this phase has been dated to 2480 ± 120 B.P.

The NAP diagram, Fig. 5, shows that the Cerealia curve at Kirkkojärvi is composed chiefly of *Avena* and *Hordeum* types. *Secale* is restricted to the topmost samples.

Amongst the naturally-occurring NAP species the Gramineae occupy the dominant position in the diagram, followed by Rosaceae *(Filipendula)*, Ranunculaceae and Cyperaceae types. Both the total NAP proportion and the number of NAP species are seen to increase considerably along with the appearance of Cerealia around the 175 cm level, and the same pattern is found in the case of the rise in Cerealia at 35 cm. We shall return to examine the NAP species in detail at a latter juncture.

The boring taken at Loimansuo reaches a depth of 350 cm. The lower part of the core is composed of *Carex-Equisetum-Phragmites* peat, which gradually merges into *Carex* peat. From the 300 cm level upwards this is mixed with *Sphagnum*, and from 280 cm the core is composed entirely of *Sphagnum* peat (Figs. 6, 8, 9). Between 60 cm and 140 cm the profile contains eight darker, more humified layers (cf. the 'recurrence surfaces' of GRANLUND 1932, BRANDT 1948), at which the pollen grains found are both less in number and severely damaged. The loss-on-ignition curve (Fig. 8) suggests an increase in inorganic matter at the 150—160 cm level and in the upper 60 cm.

Radiocarbon dates:

Depth in cm	Lab.no.	Age B.P.	Event dated
40— 44	Hel-355	420 ± 140	Subzone boundary IXa/IXb
146—150	Hel-356	1970 ± 100	Decline in cultural indicators
320—330	Hel-357	3400 ± 130	Rise in Picea

In terms of pollen chronology the diagram stretches to the end of the Sub-boreal.

The *Betula* peak at 330—340 cm must presumably represent the local dominance by deciduous trees characteristic of a shore phase. Elsewhere the proportion of *Betula* remains more or less constant, around 50 % of AP in the section 150—320 and around 40 % above this.

The proportion of *Pinus* pollen increases towards the top of the diagram. From an average of 30 % of AP in sub-zone IXa it rises steadily to 60 %, and sustains an average of 50 % in sub-zone IXb.

The proportion of *Alnus* varies in the range 2—20 % of AP, though no distinct phases can be determined.

After its spread to the area, dated to 3400 ± 130 B. P., *Picea* rapidly rises to represent 25 % of AP, later settling at an average of 15 % and only occasionally reaching this initial level again. A noticeable drop in *Picea* pollen occurs at the sub-zone IXa/IXb boundary, so that it sometimes accounts for only 5 % of AP, though its proportion increases again as sub-zone IXb progresses.

A gradual decline in Quercetum Mixtum may be seen towards the surface of the bog, with only sporadic occurrences of the thermophilous tree species in sub-zone IXb.

There is a weak but consistent occurrence of *Juniperus* in the depth of 5—50 cm. On the other hand, *Salix* is poorly represented and scattered throughout, its peak at 290—300 cm probably being connected with the coastal location of the area at that time.

Considerable fluctuations are seen in the AP/NAP ratio. The earliest peak for NAP is indicative of a coastal vegetation. Here NAP accounts for almost one third of total pollen. The proportion then falls to approx. 5 % and maintains this level until the appearance of the humified layers, whereupon herb pollen disappears almost entirely. It is only after the uppermost of these layers that NAP is found to increase once more, though it never exceeds 25 % of total pollen in these younger deposits.

Cerealia pollen is found in this profile from the 310 cm level onwards, and its occurrence may be shown to be associated with indicators of agriculture, an analysis of which will be undertaken later. A decline in total amounts of cultural indicators is found at 148 cm, a level which has been dated to around the birth of Christ (1970 ± 100 B. P.). The Cerealia total is composed almost entirely of *Avena* type in sub-zone IXa, and it is only in sub-zone IXb that all the cereals come to be represented (Fig. 9).

The dominant herb species varies at different points in this diagram. The Gramineae peak at the base of the diagram is presumably due mainly

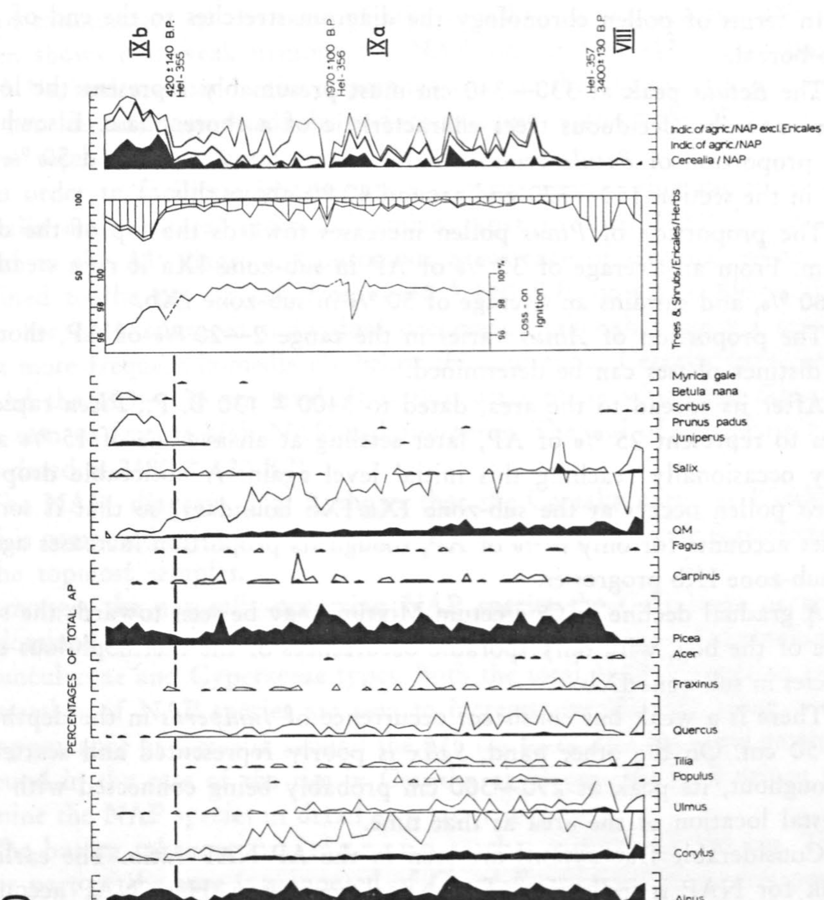


FIG. 8. Loimansuo: Relative arboreal pollen diagram with radiocarbon dates.

to the presence of coastal *Phragmites* stands. As the bog dries out the proportion of *Carex* increases, and later that of Ericales type pollen. These then appear to alternate with variations in the water balance of the bog

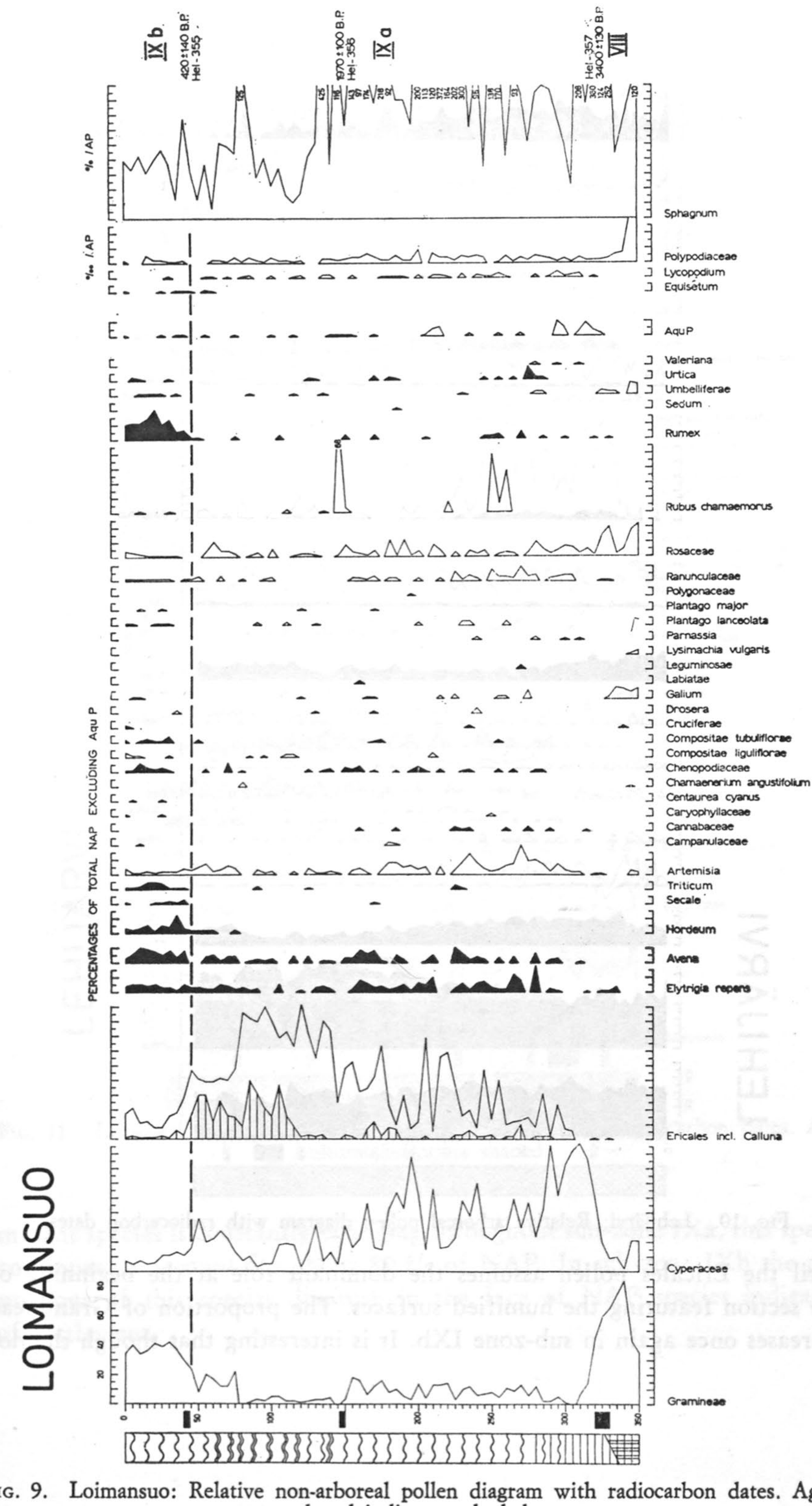


FIG. 9. Loimansuo: Relative non-arboreal pollen diagram with radiocarbon dates. Agricultural indicators shaded.

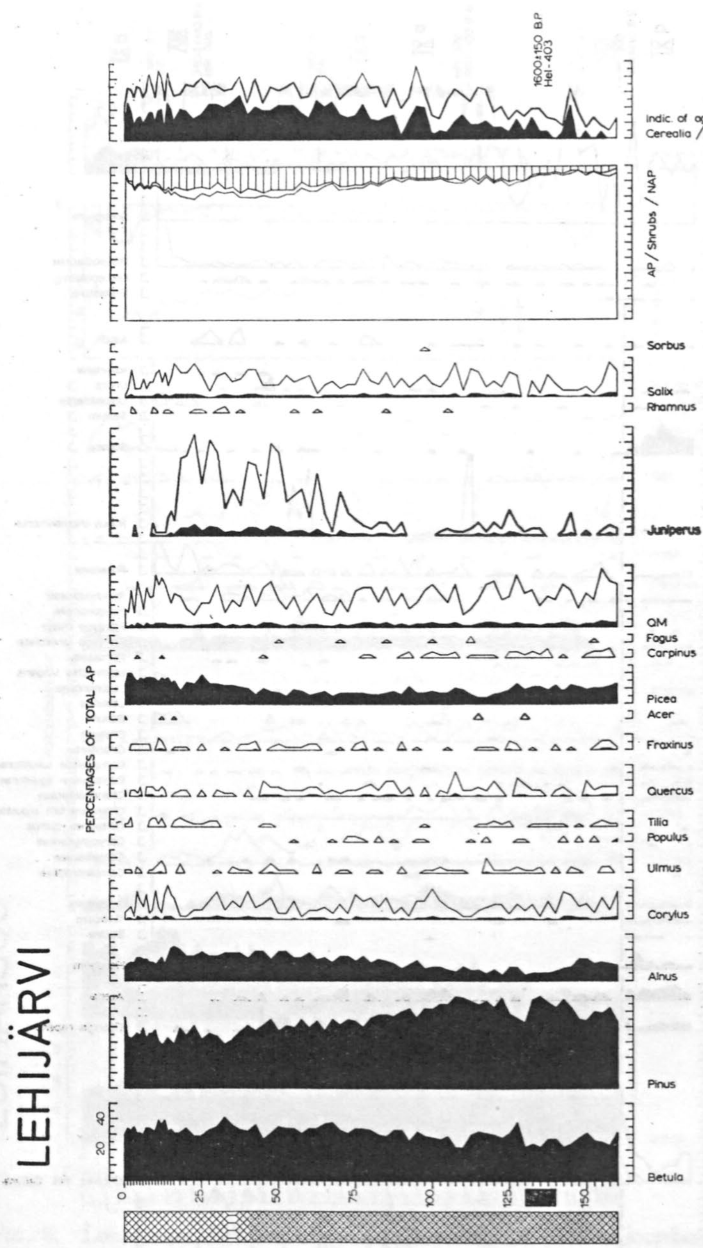


FIG. 10. Lehijärvi: Relative arboreal pollen diagram with radiocarbon dates.

until the Ericales pollen assumes the dominant role at the beginning of the section featuring the humified surfaces. The proportion of Gramineae increases once again in sub-zone IXb. It is interesting that though the do-

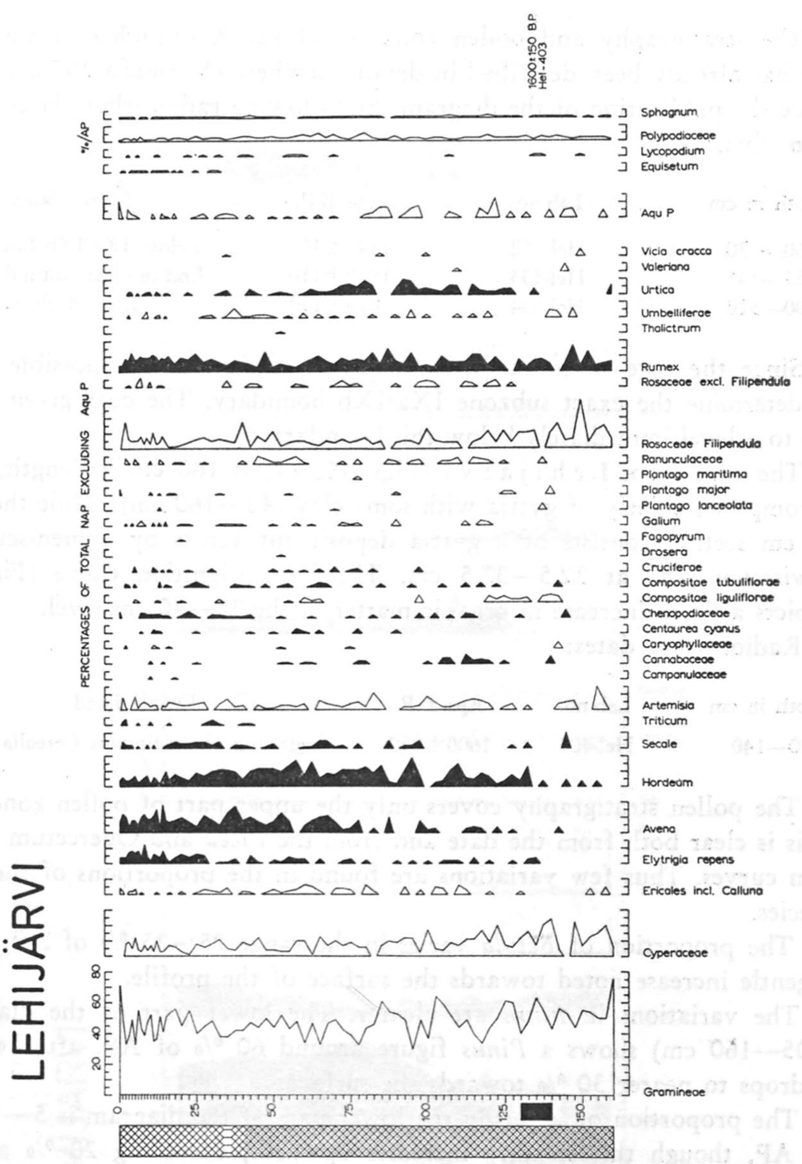


FIG. 11. Lehijärvi: Relative non-arboreal pollen diagram with radiocarbon dates. Agricultural indicators shaded.

minant species is constantly changing throughout sub-zone IXa, this species continues to account for about 80 % of NAP. In sub-zone IXb the proportions of this species diminish in the face of NAP species indicative of settlement.

The stratigraphy and pollen zonation of the K a t i n h ä n n ä n s u o site has already been described in detail elsewhere (VUORELA 1970, 1972). Since the publication of the diagram the following radiocarbon dates have been obtained.

Depth in cm	Lab.no.	Age B.P.	Event dated
60— 70	Hel-352	1140±100	Below IXa/IXb boundary
135—145	Hel-353	1940±110	End of clear cultural phase
300—310	Hel-354	3420±150	Rise of *Picea*

Since the core itself had been disposed of, it was not possible here to determine the exact subzone IXa/IXb boundary. The date given applies to a level immediately below this boundary.

The core from L e h i j ä r v i (Figs. 10, 11) is 160 cm in length, and is composed chiefly of gyttja with some clay (40—160 cm), while the top 40 cm section consists of a gyttja deposit cut across by a meniscus of *Equisetum* peat at 32.5—37.5 cm. The loss-on-ignition curve (Fig. 7) depicts a sharp increase in organic matter at the 35—40 cm level.

Radiocarbon dates:

Depth in cm	Lab.no.	Age B.P.	Event dated
130—140	Hel-403	1600±150	Beginning of continuous Cerealia curve

The pollen stratigraphy covers only the upper part of pollen zone IX. This is clear both from the date and from the *Picea* and Quercetum Mixtum curves. Thus few variations are found in the proportions of the tree species.

The proportion of *Betula* varies in the range 25—35 % of AP, with a gentle increase noted towards the surface of the profile.

The variations in *Pinus* are clearer. The lower part of the diagram (105—160 cm) shows a *Pinus* figure around 60 % of AP, after which it drops to nearer 30 % towards the surface.

The proportion of *Alnus* in the lower part of the diagram is 5—15 % of AP, though this steadily increases upwards, exceeding 20 % at the 15—20 cm level.

There are comparatively few fluctuations in the *Picea* curve. In the lower part of the profile (160—40 cm) it averages 10 % of AP; and then it increases markedly after 40 cm, to reach 20 % in the topmost samples.

The Quercetum Mixtum curve is exceptionally consistent in this diagram. The curves for the individual species show that the thermophilous arboreal species, *Corylus, Ulmus, Tilia, Quercus* and *Fraxinus,* all continue

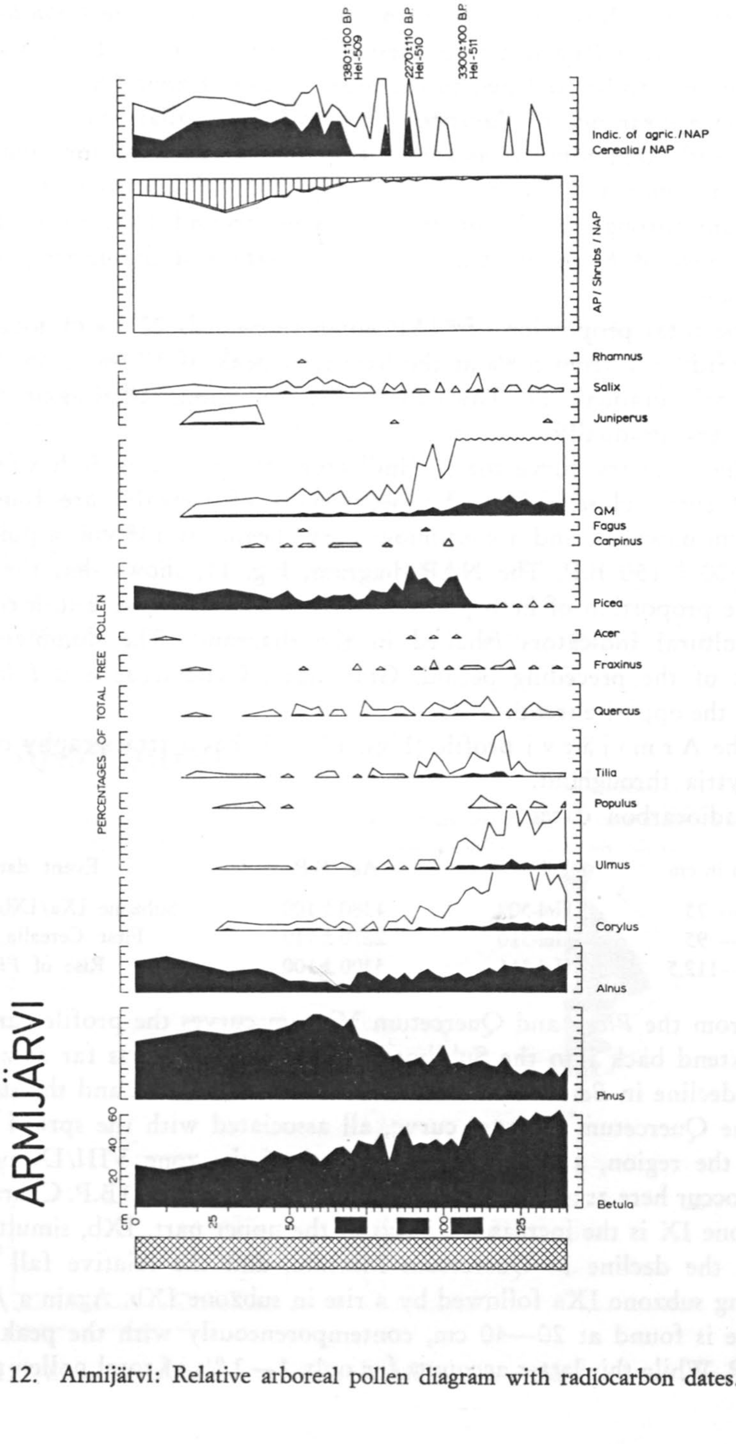


FIG. 12. Armijärvi: Relative arboreal pollen diagram with radiocarbon dates.

undiminished through to the surface of the profile, while *Populus, Carpinus* and *Fagus* (the last two presumably not denoting local occurrence) can be seen to be confined to the older phases of zone IX.

The appearance of *Juniperus,* matched by similar events at Kirkkojärvi and Loimansuo, is located between 15 and 85 cm and comprises at times as much as 7 % of AP. The proportion of *Salix* remains relatively constant throughout the diagram, varying around 1—2 % of AP. The occurrence of *Rhamnus* is a conspicuous feature of the upper part of the diagram.

The total proportion of NAP nowhere exceeds 20 % of total pollen. Its steady rise from 5 % at the base to a peak of 17 % at 35 cm is an extremely gradual one. Towards the surface it diminishes again to 10 %, also very gradually.

The summary curve for the indicators of agriculture follows the total NAP curve closely. Sporadic occurrences of Cerealia are found from 155 cm onwards, and a continuous curve begins at 135 cm, a point dated to 1600 ± 150 B.P. The NAP diagram, Fig. 11, shows that the increase in the proportion of herb pollen is due in a large measure to a rise in the agricultural indicators (shaded in the diagram). The dominant pollen types of the preceding period, Gramineae, Cyperaceae and *Filipendula,* show the opposite trend.

The Armijärvi profile (Figs. 12—15) has a stratigraphy composed of gyttja throughout.

Radiocarbon dates:

Depth in cm	Lab.no.	Age B.P.	Event dated
65 — 75	Hel-509	1380 ± 100	Subzone IXa/IXb boundary
85 — 95	Hel-510	2270 ± 110	First Cerealia pollen
102.5—112.5	Hel-511	3300 ± 100	Rise of *Picea*

From the *Picea* and Quercetum Mixtum curves the profile can be seen to extend back into the Sub-boreal at least, possibly as far as zone VII. The decline in *Betula* and *Alnus,* the increase in *Pinus* and the steep drop in the Quercetum Mixtum curve, all associated with the spread of *Picea* into the region, are all features typical of the zone VIII/IX boundary, and occur here at a level of 100 cm, dated to 3300 ± 100 B.P. Characteristic of zone IX is the increase in *Pinus* in the upper part, IXb, simultaneously with the decline in Quercetum Mixtum, and the relative fall in *Picea* during subzone IXa followed by a rise in subzone IXb. Again a *Juniperus* phase is found at 20—40 cm, contemporeneously with the peak in total NAP. While this latter accounts for only 1—2 % of total pollen at depths of 75—140 cm, it exceeds 20 % at its maximum around 30 cm. The proportion of NAP diminishes again towards the surface.

The first isolated occurrence of Cerealia pollen is found at 90 cm, and has been dated to 2270 ± 100 B.P., while its continuous presence begins at 70 cm, with a date of 1380 ± 100 B.P. At its highest this pollen type comprises 26 % of NAP. The fluctuation in the numbers of herb pollen grains seems to overemphasize the proportion of Cerealia in the older deposits. Thus it has not been deemed reasonable to construct a relative NAP diagram by species.

A comparison of the diagrams from Lehijärvi and Armijärvi (Figs. 10, 12) leads to the obvious conclusion that the basal samples of the former reflect a similar stage of vegetational development as the 80 cm level in the latter. An especially close correspondence is found here between the respective *Pinus, Alnus, Picea, Juniperus* and NAP curves. The few local differences encountered are limited to the proportions of *Betula* and Quercetum Mixtum.

The dates obtained in these diagrams for the rise of *Picea*, 3420 ± 150 B.P. at Katinhännänsuo, 3400 ± 130 B.P. at Loimansuo and 3300 ± 100 B.P. at Armijärvi, conform very well with earlier published material

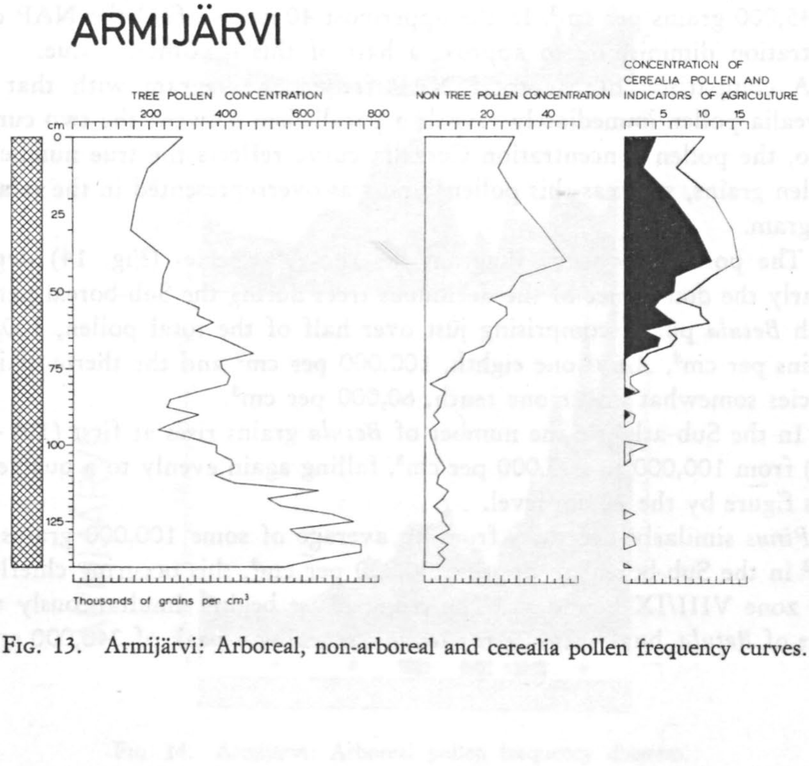


FIG. 13. Armijärvi: Arboreal, non-arboreal and cerealia pollen frequency curves.

(AARTOLAHTI 1966), especially in the case of the first two of these. At the same time they testify to the undisturbed nature of the profiles.

2. Pollen frequency diagrams from Armijärvi

A pollen concentration diagram for Armijärvi is presented in Fig. 13. One general feature to be observed in the AP curve here is the sharp decline from the Sub-boreal onwards. Whereas the pollen concentration at the base of the profile was in places as much as 760,000 grains per cm^3 it drops by the 95 cm level to 220,000 grains per cm^3. Beyond this phase, at 50—85 cm, the AP pollen frequency again increases, reaching a peak at 70 cm, when it stands at 400,000 grains per cm^3. From this point the arboreal pollen concentration again falls steadily to reach a minimum of 150,000 per cm^3 at a depth of 30 cm. A slight increase is again observable in the topmost samples. The generally rather high pollen frequencies are a consequence of the slow rate of sedimentation in the Armijärvi basin, approx. 30 cm per 1000 years.

A double pattern may be distinguished in the corresponding NAP frequency curve. Little variation is to be found in the section 80—140 cm, the figure remaining relatively steady below 10,000 grains per cm^3, while from 80 cm to 40 cm the pollen frequency increases steeply to a maximum of 45,000 grains per cm^3. In the uppermost 40 cm we find the NAP concentration diminishing to approx. a half of this maximum value.

A comparison of the total NAP frequency diagram with that for Cerealia pollen immediately reveals a parallelism between the two curves. Also, the pollen concentration Cerealia curve reflects the true number of pollen grains, whereas this pollen type was overrepresented in the relative diagram.

The pollen frequency diagram for the AP species (Fig. 14) depicts clearly the dominance of the deciduous trees during the Sub-boreal period, with *Betula* pollen comprising just over half of the total pollen, 400,000 grains per cm^3, *Alnus* one eighth, 100,000 per cm^3 and the thermophilous species somewhat under one tenth, 60,000 per cm^3.

In the Sub-atlantic the number of *Betula* grains rises at first (105—80 cm) from 100,000 to 200,000 per cm^3, falling again evenly to a quarter of this figure by the 20 cm level.

Pinus similarly decreases from an average of some 100,000 grains per cm^3 in the Sub-boreal to approx. 60,000 per cm^3, this occuring chiefly at the zone VIII/IX boundary. The rising phase begins simultaneously with that of *Betula,* but continues for longer, reaching a peak of 240,000 grains

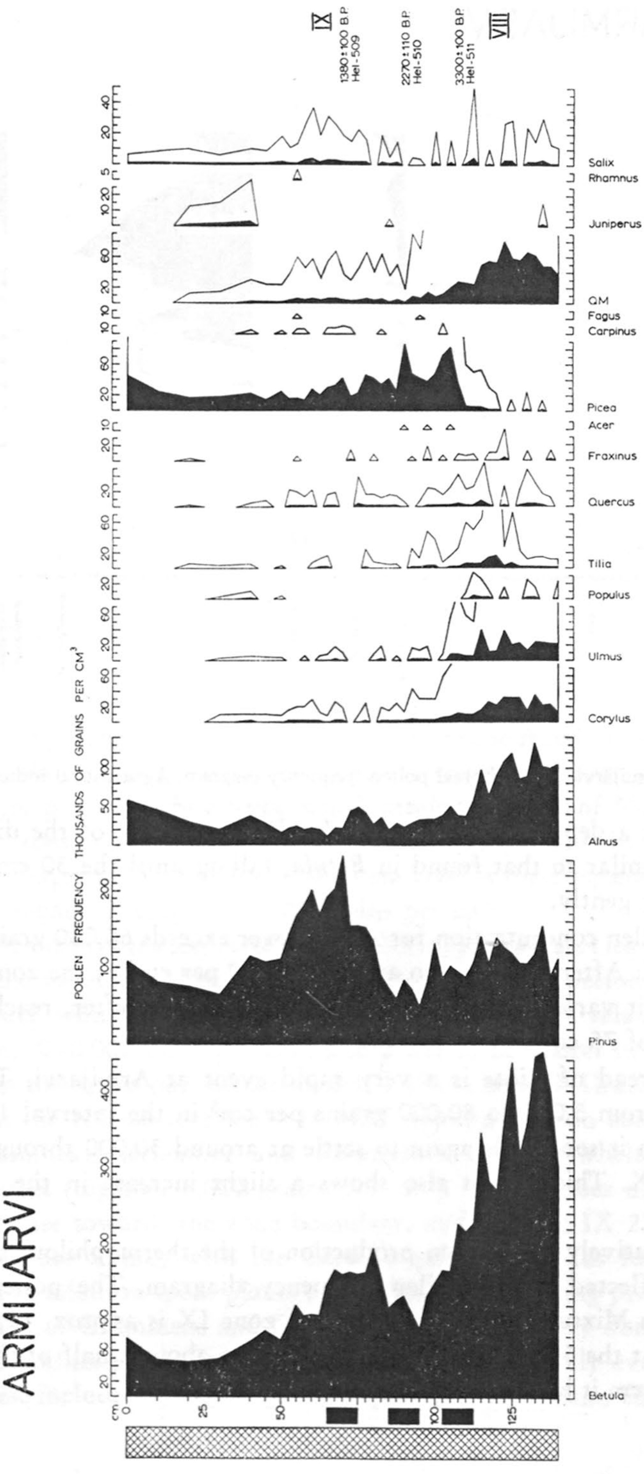


FIG. 14. Armijärvi: Arboreal pollen frequency diagram.

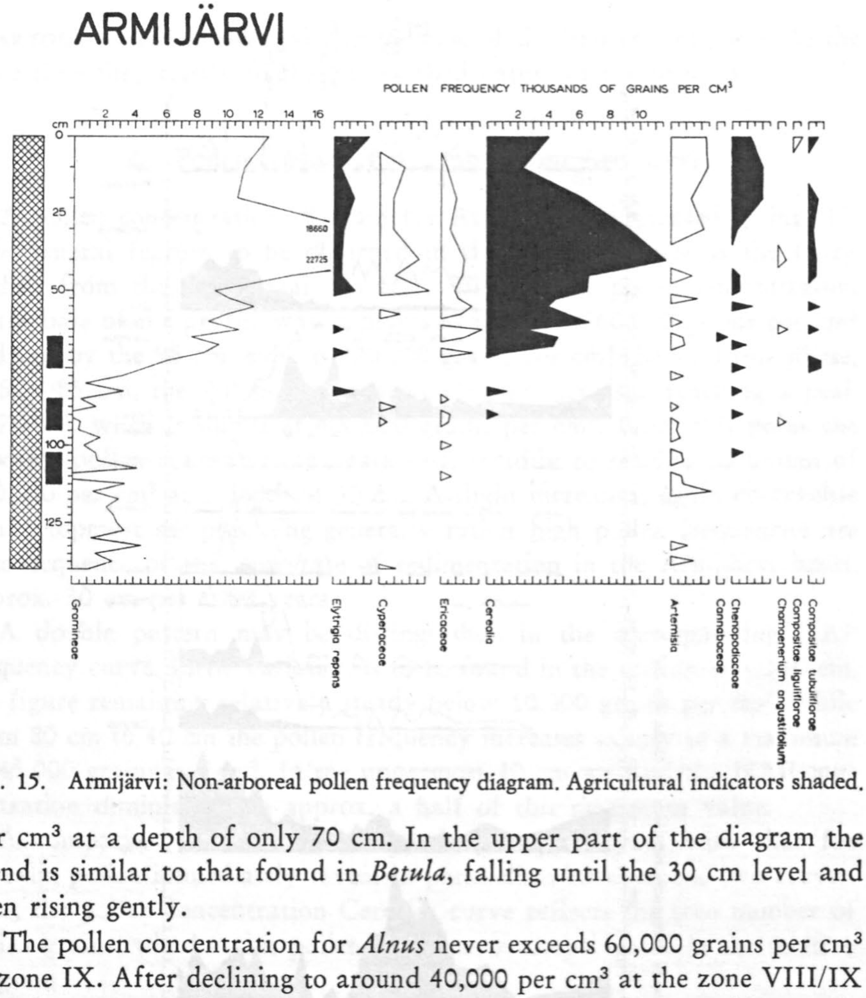


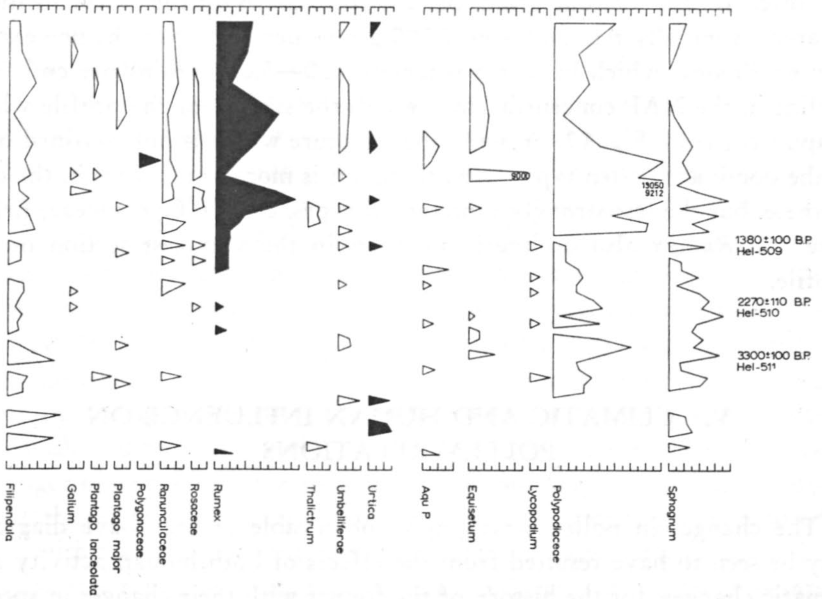
FIG. 15. Armijärvi: Non-arboreal pollen frequency diagram. Agricultural indicators shaded.

per cm³ at a depth of only 70 cm. In the upper part of the diagram the trend is similar to that found in *Betula*, falling until the 30 cm level and then rising gently.

The pollen concentration for *Alnus* never exceeds 60,000 grains per cm³ in zone IX. After declining to around 40,000 per cm³ at the zone VIII/IX boundary it varies between 20,000 and 60,000 thereafter, reaching peaks at depths of 75 cm and 40 cm and at the surface.

The spread of *Picea* is a very rapid event at Armijärvi. The species increases from 5,000 to 80,000 grains per cm³ in the interval 115—102.5 cm, though it soon falls again to settle at around 30,000 throughout most of zone IX. This species also shows a slight increase in the uppermost samples.

The relatively low pollen production of the thermophilous tree species is well reflected in the pollen frequency diagram. The pollen sum for Quercetum Mixtum in the older part of zone IX is approx. 10,000 grains per cm³. At the 50 cm level it falls rapidly to about a half of this amount and by 20 cm it has died out altogether.



At the stage where its occurrence is most pronounced, at a depth of 20—40 cm, the frequency of *Juniperus* pollen varies in the range 15,000—40,000 grains per cm³, while *Salix*, which attained figures of 50,000 grains per cm³ in zone VIII, dimishes to around 10,000 per cm³ by the upper part of the diagram. Only at the 50—75 cm level is the frequency of *Salix* pollen any higher, averaging 20,000 grains per cm³.

The pollen concentration NAP diagram (Fig. 15) reveals clearly the two phases in the vegetational history of the site during this period. The zone VIII deposits, which have already been shown to contain relatively little herb pollen, <10,000 NAP per cm³, also prove to be poorer in number of species than the upper part of the diagram. If the zone VIII/IX boundary is placed at the 100 cm level only 14 NAP types appear in zone VIII, of which Gramineae, *Artemisia* and *Filipendula* are overwhelmingly the dominant ones (together 8,000 grains per cm³). The number of species is seen to increase towards the zone boundary, and in zone IX 22 different pollen types are found, with the Cerealia pollen taken as forming one group, and in addition spore plants and aquatic plants being present. With the exception of Gramineae and Cerealia, which are clearly dominant, the other wind-pollinated species are found to be comparatively evenly represented. These include *Elytrigia repens*, Cyperaceae, *Artemisia*, Chenopodiaceae and *Rumex*. On the other hand *Urtica*, which is also wind-pollinated, is poorly represented. Whereas the maximum values for the dominant species reach 10,000—20,000 grains per cm^3, the figures for the others mentioned above generally remain below 2,000 grains per cm^3, with the one exception of *Rumex*, which in places reaches 4,000—5,000 grains per cm^3. The decline in the NAP concentration towards the surface of the profile which is apparent from Fig. 12, proves to be a feature which is not confined only to the dominant pollen types, even though it is more in evidence in the case of these, but the less strongly represented types, chiefly Cyperaceae, Ericaceae and *Rumex* also decline in numbers in the youngest section of the profile.

V. CLIMATIC AND HUMAN INFLUENCE ON POLLEN RELATIONS

The changes in pollen stratigraphy observable in the above diagrams may be seen to have resulted from the effects of both human activity and climatic changes, for the history of the forests with their changes in species composition is closely bound to these factors.

The most significant climatic feature is the transition around 500 B.C. from the Sub-boreal period, zone VIII, which may be considered to some extent as a warm phase, to the cool, damp Sub-atlantic period, zone IX. In practice this implies a considerable reduction in the thermophilous species at this point in the stratigraphy. These, and in part also *Betula* and *Alnus*, are replaced by an increasing proportion of evergreen species, the decisive influence being the simultaneous spread of *Picea* into Southern Finland (Aartolahti 1966, Moe 1970, Tallantire 1972 a, b). Although other minor climatic fluctuations may be distinguished during the Sub-atlantic period (Sirén 1961, Liljeqvist 1970), these are impossible to discern in pollen diagrams (Donner 1972, 1974).

The largest changes in the pollen concentrations and proportions in zone IX are caused by settlement, and in particular by the agriculture which followed settlement. The clearance of forest for settlement and roadways serves to alter the species composition and often to bring in new species (cf. Linkola 1916) which would not be found under natural conditions. Human transport systems in all their forms then continue both to move species from one locality to another, and also to carry pollen beyond the limits of distribution of the species concerned (Vuorela 1973).

Agriculture occupies an extremely important position in vegetational development as an active propagator of certain plant species. Forest clearance for farming follows a regular pattern of increasing the proportions of certain tree species, e.g. *Pinus,* while at the same time selectively reducing the amounts of others, e.g. the "noble" deciduous trees, *Picea* etc. Similarly, certain species may be found to profit indirectly from clearance, chiefly as a result of sharp changes in illumination in forests surrounding field areas. In Southern Finland this mainly applies to *Betula* and *Alnus,* which commonly appear as pioneer species on the site of fellings and in the forests surrounding cultivated areas. The increased representation of these species in sediments corresponding to clearance phases may be due not only to the absolute increase in the number of specimens, but also to the very much greater intensity of flowering associated with increased illumination.

As has been established on an earlier occasion (Vuorela 1972) an agricultural phase appears in the *Alnus* and *Betula* pollen curves in connection with slash and burn cultivation as it is typically practised. This feature is no longer observable in the sediments corresponding to the last centuries, for as the areas under cultivation increase, the percentage of field-edge forest within the total forest area diminishes, as does the area of fellings. Also, as the fields become more firmly established a tighter vegetation forms, and one which comprises all the forest levels, so that the spread of local pollen to the surrounding areas is effectively limited (Jensen & Bøgh 1942, Dengler 1955, Tauber 1965, 1967). In such cases the dominance of *Betula* and *Alnus* becomes a comparatively local feature which diminishes rapidly in magnitude with distance from the site (Andersen 1967, Vuorela 1973). In older cultures grazing also had the effect of favouring the rise of predominantly deciduous forests. This has nowadays been replaced by the cultivation of hay and fodder crops within the field area proper, which does not affect the species composition of the forests to anything like the same extent. On the other hand the effect of hay cultivation on the AP/NAP has become a factor to be reckoned with in more recent centuries. In spite of this, the relative increase in *Pinus* pollen, for example, clearly indicates the continuing effect of climatic factors on the proportions of the tree species in Southern Finland.

An abundance of *Juniperus* pollen has often been interpreted as an indicator of grazing in the area (Fries 1958, Berglund 1966). The reason why it is relatively seldom suggested as being associated with early cultural phases may lie in its difficulty of recognition. The present results and those of Fries (1961, 1963) from the Aaland Islands point to this pollen type as a typical cultural indicator in Finland, at least in the south-western parts of the country (cf. FRIES 1963, 1969, BERGLUND 1969, KÖNIGSSON 1969 a, b and HUTTUNEN & TOLONEN 1972). The absence of *Juniperus* from the Katinhännänsuo diagram may be due to the author's earlier failure to recognize this pollen type.

In an earlier paper (VUORELA 1972) the herb species were grouped on the basis of their possible interpretation as indicators of agriculture, particularly as practised during recent centuries. In this present work the Cerealia pollen and the agricultural indicators associated with it are taken as a basis for interpretation. It should be mentioned at the outset that although the absence of the former group is not alone enough to show that there was no agriculture in a given district, the presence of this group is a sure sign of agriculture, and this may be further reinforced by the added presence of pollen grains from the latter group. The indicators of agriculture include *Elytrigia repens,* Chenopodiaceae, *Centaurea cyanus,* Compositae tubuliflorae, Cruciferae, Labiatae, Polygonaceae, *Rumex acetosella, Urtica* and Cannabaceae. If none of these associated indicators is found, there is reason to suspect that the Cerealia pollen found may well be in fact one of those species which is difficult to distinguish from the Cerealia, such as *Elymus arenarius* or *Elytrigia repens.*

Although the various cereals are accounted for separately in the NAP diagrams, errors in identification so easily arise, especially between *Avena* and *Hordeum,* when using an ordinary light microscope, that it would be dangerous to try to match the history of cultivation with the individual curves in any detailed manner. One general feature to be noted is the relatively small proportion of the wind-pollinated *Secale* pollen compared with that of the other species, especially since it is known to have been a typical species within western Europe from the Iron Age onwards (JESSEN & HELBAEK 1944, MIKKELSEN 1952, JESSEN 1953, HJELMQVIST 1955, GODWIN 1956, FRIES 1961). But the cleared fields where rye was grown in early times in Finland were generally small, scattered patches situated in places remote from the settlement villages, while barley and oats were cultivated in permanently cleared fields close by the villages. Thus the location of the sampling sites almost without exception in the proximity of settlement villages may explain the predominance of the latter species in spite of their lower pollen production. In later centuries, as slash and burn cultivation declined in importance, the proportion of rye cultivated also declined (Vuorela 1970), which may possibly be the reason for the continued low proportion of *Secale* pollen.

Under the conditions prevailing in Southern Finland the major tree species, chiefly *Betula, Pinus* and *Alnus* produce such large amounts of pollen that the human interference features discussed above are very nearly obscured. Thus the distinguishing features of phases of early agriculture in diagrams from Southern Finland are very delicate and often difficult to perceive compared with the variations in the figures for cultural indicators in diagrams from southern Scandinavia and England (IVERSEN 1941, 1949, 1967, GODWIN 1948, M.-B. FLORIN 1957, S. FLORIN 1961, NILSSON 1961, BERGLUND 1969, KÖNIGSSON 1969 a, b, HICKS 1971, WELINDER 1973). The principal requirement appears to be a sufficiently large pollen sum per sample, 500—1000 AP, so that the poorly represented NAP species stand out adequately within the total pollen.

The combined diagram, Fig. 16, places side by side the curves for all the sites which represent the cultural indicators plus those AP curves found to be affected most by varying degrees of human interference, *Picea, Betula, Juniperus* and *Alnus*. The Quercetum Mixtum curves appear to be so closely dependent on local conditions that they can scarcely be considered comparable one with another. The curves are presented on a single absolute time-scale based on the radiocarbon dates obtained for the profiles. This, within certain limits of error, enables the differences between the sites to be examined more closely. We shall return to the interpretation of the settlement history of these areas below.

The figures denoting the field area at each site included in this diagram are based on the historical maps contained in Fig. 2, and represent the percentage of field within the map area (9 km^2). Since no dates are available for subzone IXb the diagram assumes a constant rate of sedimentation. Thus it is impossible to avoid misplacements of some of the field area figures, and they cannot be taken as being more than guidelines. They do, however, serve to demonstrate the limitations of relative pollen figures as reflectors of the area and standard of cultivation, a feature which has previously been noted with reference to recent pollen rain (VUORELA 1973).

The following attempts to examine the manner in which the abovementioned possible climatic and human influences on vegetation are reflected in these diagrams.

No significant changes may be distinguished in the arboreal pollen curves in the Kirkkojärvi diagram (Figs. 4, 16) which could be attributed with any certainty to a climatic change during the Sub-atlantic period. The most outstanding feature is the gradual decline in the thermophilous tree species towards the present time, though it is impossible to determine the part played by climate in this, for since the decline in the Quercetum Mixtum curve coincides in time with the appearance of Cerealia and the respective curves then continue to be in some measure comple-

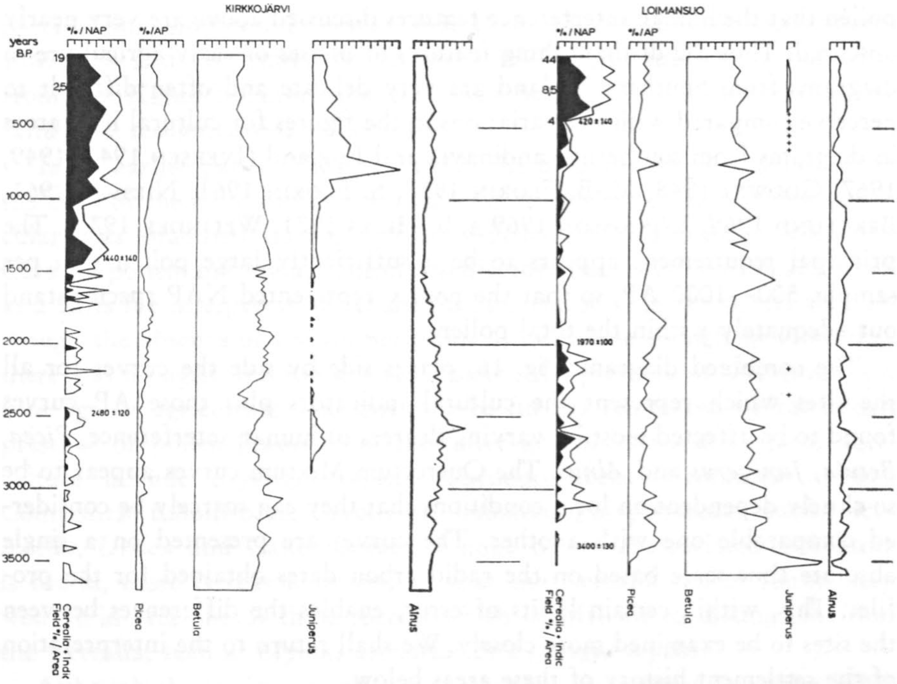
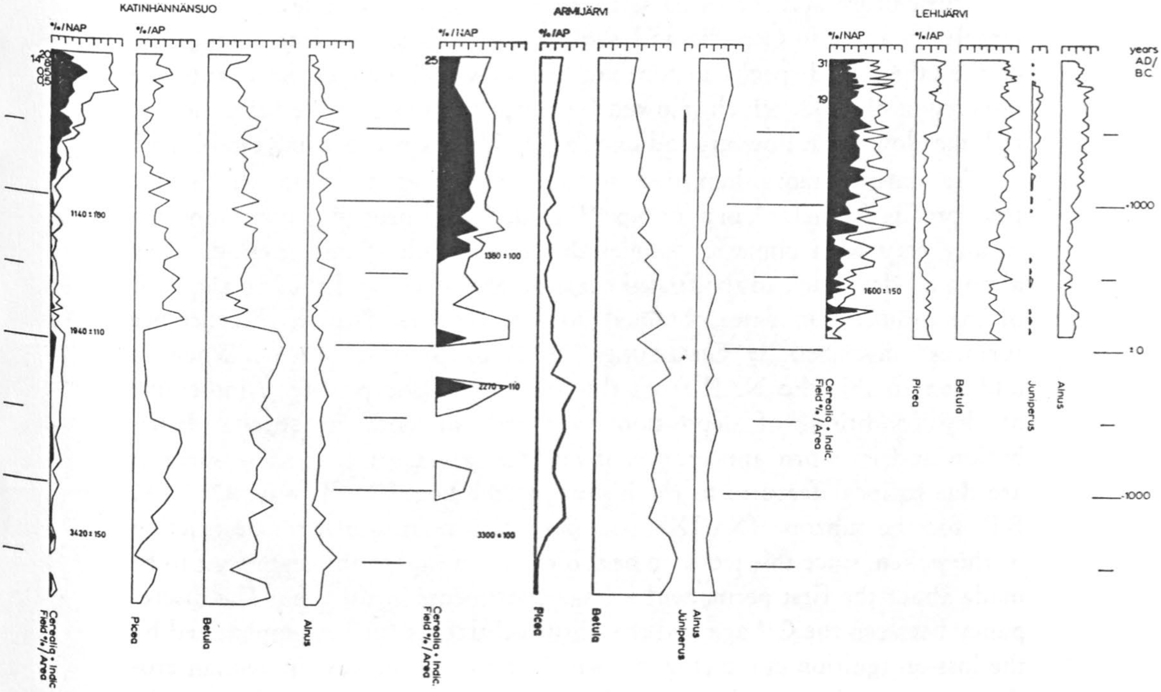


FIG. 16. Comparison of the occurrence of agricultural indicators with arboreal pollen relations. The diagrams are drawn on an absolute time-scale based on the C[14] dates. The figures in the upper parts of the diagrams refer to the extent of field area as a percentage of the total area of the study site.

mentary to each other, it is probable that without human interference there would be a higher proportion of pollen from the "noble" deciduous trees than is found at present. The northern limits of these species determined on the basis of climate alone (ERKAMO 1960) support this opinion. The brief decline in the proportion of *Betula* at the 110—125 cm level, corresponding to a date of 2,400 B.P. may well be an accidental, local phenomenon. Nevertheless it does occur at a point marked by a definite decline in several cultural indicators including *Alnus, Juniperus* and the herbs. This gives reason to suspect that this may represent a period of reforestation and an increase in the proportion of coniferous species.

It would be dangerous to attribute the slight variations in the *Picea* curve directly to either human or climatic factors. Spruce is known to have suffered more than most other tree species from the effects of slash and burn cultivation (HEIKINHEIMO 1915), and the complementary reaction of the *Picea* curve to that representing the indicators of agriculture around 2000 B.P. is of importance in this respect. On the other hand, it is difficult



to say whether the peak in *Picea* in the upper part of the diagram is exclusively the result of the establishing of more permanent fields at the expense of the deciduous trees or whether climatic factors are also involved.

A very clear correlation may be seen in this diagram between the occurrence of *Juniperus* and that of the cultural indicators among the herb pollen.

In the detailed relative NAP diagram (Fig. 5) a number of the species indicative of human settlement are found to be represented from the very lowest parts of the profile onwards. As the sediments at the base of this profile represent the time of the separation of Kirkkojärvi from the sea those species characteristic of open ground, Chenopodiaceae and *Rumex*, must here be indicative of a coastal phase (Fries 1951). Thus the earliest reliable indicators of the presence and activity of man will be the first Cerealia grains, at a level of 155 cm. The NAP species, which increase simultaneously, continue from this level up to the surface of the deposit, being relatively well represented, though intermittently. These species include a number of agricultural indicators, e.g. Cannabaceae, Chenopodiaceae, Compositae tubuliflorae, Cruciferae, *Rumex* and *Urtica.* They do not, however, form any clearly definable phase, though a period of intensified agriculture and increased settlement is indicated at a level of 40 cm, largely by a rise in Cerealia and *Rumex* type pollen. The low proportions of the other weed species in subzone IXb may well be connected with the poverty of the soil, which allowed few opportunities for the formation of rich meadows or fallow ground once the field area had become established.

The darker, more humified surfaces found at 55—145 cm in the peat profile from Loimansuo (Figs 8, 9) are probably not connected in any way with climatic changes during the Sub-atlantic period. They almost all date back to the first thousand years A.D., and thus on the basis of the radiocarbon dates obtained do not correspond to the "recurrence surfaces" described by GRANLUND (1932) or BRANDT (1948). When in addition to this the NAP from this portion of the profile is indicative of dry conditions of deposition by virtue of both its species distribution and its worn appearance, it becomes apparent that these surfaces are due to local features in the history of the bog. The date of 420±140 B.P. for the subzone IXa/IXb boundary also points to some destruction of the pollen, since this seems to be too recent to enable any statement to be made about the first permanent village settlements in the area. The discrepancy between the C^{14} age and the historical data is further emphasized by the loss-on-ignition curve (Fig. 8), which shows an increase in aeolian erosion corresponding to the intensification of agricultural activities in the area. In other words, the intensification of agricultural activities is reflected not only by a rise in the Cerealia pollen curve, but also by a higher content of mineral matter in the peat sediments (Fig. 17). The grain size of the detrital material from the sample 5—10 cm (analyzed in Table 1) is 0.06—0.005 mm, a range which is characteristic of aeolian material. The mineral deposit may thus be assumed to have been transported by the wind from the surrounding fields. This interpretation is also supported by the occurrence in the material of quartz and various easily-weathered minerals such as chlorites, biotite and carbonates. The latter may originate from the lime used as a fertilizer on peaty soils.

In view of the richness of the local vegetation and the generally favourable climate, it is possible that the fall in the Quercetum Mixtum curve in subzone IXb reflects chiefly an increase in the influence of man on the area and perhaps only secondarily a deterioration in the climate. The association of the *Juniperus* period in subzone IXb with human activity is proof that the contemporaneous fall in Quercetum Mixtum may be a consequence of forest clearance and grazing.

The dry phase mentioned above at 55—145 cm also affects the preservation of the NAP grains, rendering it difficult to define the true extent

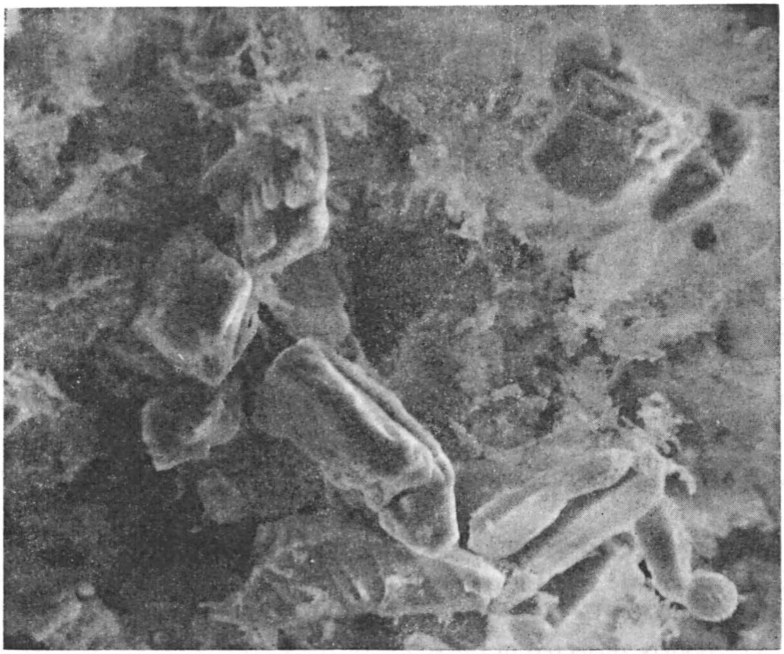


FIG. 17. Mineral matter from Loimansuo at 20—25 cm. 3000 x. SEM, Viikki.

of the fluctuation in cultural indicators. It may simply be noted that these indicators, *Elytrigia repens*, Chenopodiaceae, Compositae tubuliflorae, *Rumex* and *Urtica*, tend to follow the fluctuations in Cerealia in the Loimansuo diagram. With the exception of the first-mentioned, the proportion of these is very low in subzone IXa, although relatively consistent in the case of Chenopodiaceae and *Rumex*, for instance. A much greater effect of

TABLE 1. (Analysed by K. Kinnunen) Sample: 50—100 mm. Detrital inorganic grains. Ø 0.06—0.02 mm.

Minerals	% (200 grains)
Quartz	72.0
Biotite	7.0
Plagioclase	6.5
Amphibole	5.0
Chlorite	2.5
Carbonate	2.0
Zircon	0.5
Pyroxene	1.0
Tourmaline	1.5
Microline and orthoclase	0.5
Rock fragments	
Biotite schist	

agriculture on the vegetation is depicted in subzone IXb both by Cerealia and chiefly by the Chenopodiaceae, Compositae tubuliflorae and *Rumex* pollen.

The human influence on AP relations in subzone IXa is observable most clearly of all in K a t i n h ä n n ä n s u o (Fig. 16; cf. VUORELA 1970, 1972). The very sharply defined *Picea* minimum at a depth of 130—220 cm, the upper limit of which has been dated to 1940±110 B.P., may be interpreted as a feature attributable to slash and burn cultivation, a view which is supported by the simultaneous occurrence of peaks in both Cerealia and *Betula.* The decline in the *Picea* curve at the beginning of sub-zone IXb may similarly be explicable by local clearance and associated slash and burn cultivation. Elsewhere there is little in the AP relations to suggest the influence of man.

As mentioned above, the surroundings of Katinhännänsuo are known to have remained uncultivated for a considerable time, the oldest permanent fields being identifiable only from the 1840 survey. The increase in field area from the small forest clearings which are known to have existed in the mid-eighteenth century to the present extent of cultivation may be said to be poorly reflected in the shape of the Cerealia curve. The reduction in indicators of agriculture in the uppermost samples is a feature which recurs at a number of sites.

The variations in the AP relations found in the A r m i j ä r v i diagram may be divided into those attributable to the natural forest succession and those attributable to human activity; though the borderline between these is by no means a clear-cut one even in this case. Perhaps the only case to fall entirely into the former category is the spread of *Picea* at the 105 cm level, dated to 3300 ± 100 B.P. The climatic deterioration may well also be reflected in part in the decline in the Quercetum Mixtum at the same point in time.

The influence of man may be detected with the greatest degree of certainty in the appearance of Cerealia pollen around 2270 ± 110 B.P. It is probable that the fall in the proportion of *Picea* and Quercetum Mixtum pollen simultaneously with this event would be connected with clearance activity.

The change in forest composition at the zone VIII/IX boundary is also apparent from the pollen concentration values (Fig. 14). The rapid advance of *Picea* has a pronounced effect on the status of the deciduous trees in particular, and it is evident that the drop in the amount of *Betula, Alnus* and Quercetum Mixtum pollen is consequent upon the spread of spruce, for the species would effectively shade out the deciduous trees, with their greater light requirements (KALELA 1961). Although the increase in the proportion of *Picea* pollen may not be the principal feature to be noticed in the diagram, since *Picea* is in any case a low pollen producer, its advance is reflected all the more strikingly in the case of these other species whose pollen production is higher.

The absolute pollen frequencies also serve to highlight certain effects of human interference. As Cerealia appears we also see an immediate increase in *Betula* at the expense of *Picea*, an example of the pioneer function of *Betula* in connection with forest clearance and the abandonment of fields. The corresponding increase in *Pinus* pollen occurs somewhat later, this too very probably constituting evidence of an improvement in light conditicns. The shorterm rise in *Alnus* pollen encountered at the 75 cm level may also be connected with human activity.

One feature stands out very clearly in this diagram which was previously noted in the Katinhännänsuo diagram on the basis of relative pollen values (VUORELA 1972), namely that the positive response of *Betula* to forest clearance and small-scale agriculture is reversed again as the Cerealia values increase, i.e. as the area under cultivation is extended and agriculture becomes more firmly established.

The decline in the absolute NAP frequency towards the surface of the profile, as noted above in Fig. 15, is in conflict with the notion of an expansion in field area. This may be due in part to advances in agricultural techniques, resulting in a reduction in the proportion of weeds, and perhaps also to the digging of field drains. A further factor may be the higher water content in the upper layers of the profile, which will have the effect of reducing the pollen frequency. This may be comparable to the reduction in absolute pollen frequency noted in peat deposits as the degree of humification declines towards the surface of the peat (HICKS 1974). This theory still does not account for the rise in AP in the uppermost samples, but would only emphasize this anomaly. Since we can scarcely think in terms of a local increase in the area of forest, one possible explanation may be an improvement in pollen production as a result of more intensive forest management. Another explanation may lie in the partial sealing off of established fields by thick intervening stands of bushes or trees. This would have the effect of filtering out pollen originating from the open fields and of accentuating the proportion of arboreal pollen.

A comparison of the Cerealia curve with the total NAP curve suggests that the development of agriculture is similarly reflected in the fluctuations observed in total herb vegetation. The same features which were indicative of agriculture and settlement in the relative diagram are emphasized further in the pollen concentration diagram. It is also important to note that those individual NAP curves, e.g. that of Cerealia, which in relative diagrams were overemphasized as a result of the low total NAP figure, prove in the pollen frequency diagram to be better indicators of the small size of the cultivated area. Similarly, the overwhelming predominance of the Gramineae as pollen producers is also apparent in this diagram. The indicators of agriculture found in the Armijärvi NAP diagram are, in addition to Cerealia, Chenopodiaceae, Compositae tubuliflorae, Polygonaceae, *Rumex*, *Urtica* and Cannabaceae.

The occurrences of *Plantago major* and *Plantago lanceolata* at depths of 105—117.5 cm should also be interpreted as evidence of the presence of man in the area, though one cannot claim on the grounds of these alone that there was any fixed peasant culture in the surroundings of Armijärvi at that date (3300 ± 100 B.P.). In the same way the individual grains of *Urtica* which appear immediately before the *Plantago* do not alone constitute evidence of the existence of agriculture in the absence of other cultural indicators. It is more probable that these arise from natural occurrences of *Urtica* within a herb-rich forest vegetation. On the other hand, when we bear in mind the relatively small number of grains counted and the characteristic mobility of this form of agriculture, we cannot expect a period of slash and burn cultivation to leave behind it very much in the way of cultural indicators (I. Müller 1947, Firbas 1950, H. Müller 1953, 1962). In order to discover such indicators one would need to count several thousand pollen grains at each depth in the profile.

The added information on the vegetational history supplied by this absolute pollen frequency diagram from Armijärvi may be said to be of considerable value and this method of investigation is clearly a highly important one alongside the use of relative diagrams.

As mentioned above the relative pollen diagrams from Armijärvi and Lehijärvi are practically identical in those parts which are synchronous (Figs 10, 12, 16). Features brought in by agriculture may also be seen in the Lehijärvi diagram, if the lowering in the proportion of *Picea* and the increase in *Juniperus* can be interpreted as such. As the earliest occurrences of Cerealia pollen are obviously located below the profile studied here, no information can be gained on the influence of the oldest forms of agriculture on the arboreal pollen relations. The generally good soil and local climatic conditions at Lehijärvi are reflected in the consistent Quercetum Mixtum curve which extends up to the present day, and in the comparatively high figures for *Rhamnus* pollen (Paquereau 1964). The local character of the first of these features is illustrated by the absence of such pollen in the uppermost samples from Armijärvi.

Typical of the Lehijärvi profile is its wide range of NAP species. The same features which were encountered at Katinhännänsuo, for example, are repeated in the various NAP types here, so that we find a continuous *Rumex* curve acting as a cultural indicator, a decline in *Urtica* with development in agriculture and a steep drop in *Filipendula* as the cultivated grains come to occupy their place within the pollen total. In addition to these, Cannabaceae, *Centaurea cyanus*, Compositae tubuliflorae and Cruciferae may be listed as NAP types whose curves follow that for Cerealia.

In response to favourable soil conditions, permanent field cultivation became established around Lehijärvi at a relatively early juncture, so that there is less evidence here than at the other sites of the slash and burn cultivation which was largerly confined to forested districts. This would seem to explain the extremely sudden appearance of Cerealia pollen, a boundary, dated to 1380 ± 100 B.P. at Armijärvi, which may be thought on the basis of the above to indicate the foundation of the present village of Nihattula, whereas the early scattered occurrences of Cerealia around 2270 ± 110 B.P. are still to be taken as signs of slash and burn cultivation. The rise of the continuous Cerealia curve at Lehijärvi, dated to 1600 ± 150 B.P. may well correspond to an early stage of field cultivation in the area.

No detailed analysis of the upper section of the diagrams (IXb) has been attempted here, and the distinction between the influence of climatic changes (Sirén 1961, Liljeqvist 1970) on the one hand and the minor fluctuations in the diagrams brought about by human agency and the natural, often local, succession observable in the vegetation (e.g. at Loimansuo) on the other is one that is impossible to make on the basis of relative pollen analysis. Nevertheless the features discussed above enable us to trace the clearly discernable influence of the establishment and intensification of agriculture over the span of the last two thousand years.

VI. COMPARISON WITH ARCHAEOLOGICAL AND HISTORICAL DATA

The pollen types indicative of the presence of agriculture, the most important of which for interpretation purposes may be considered to be the Cerealia type, are seen in the diagrams discussed above to follow a two-phase pattern of occurrence within zone IX (Figs 16, 18), the first consisting of slash and burn cultivation and a more continuous and plentiful section in subzone IXb representing more advanced field cultivation. These may be preceded in some diagrams by sporadic occurrences of indicators extending back into the various phases of the Neolithic period.

The oldest cases of Cerealia in the Kirkkojärvi diagram date back to the Bronze Age, and it is thought probable that certain stone barrows discovered at Vehmaa also date from this period. Thus the result tends to reinforce the notion of the existence of local Bronze Age habitation. On the other hand, very little cultural indicator pollen is to be found in the sediments corresponding to the pre-Roman Iron Age, there being only one occurrence of Cerealia, even though there is clear archaeological evidence of settlement at that period.

The results similarly serve to complement existing data on the prehistory of the Huittinen district (Loimansuo). The fact that the diagram covers only zone IX and the upper parts of zone VIII prevents it from shedding any light on human activity associated with the Boat-axe culture The first Cerealia grains, occurring soon after the spread of *Picea,* which has in turn been dated to 3400 ± 130 B.P. are indisputably Bronze Age in origin. It was stated above in connection with the history of the area that in this parish which is rich in Stone Age artifacts the Bronze Age constitutes an archaeological void. Nevertheless the comparatively large amounts of pollen indicative of agricultural activity suggest that the settlement known to have been present in the adjacent parishes, e.g. Kokemäki, did indeed extend into Huittinen. Settlement is known to have increased during the Iron Age, though this is not reflected in any increase in Cerealia pollen, the values for which remain low, presumably due to local factors.

Cerealia pollen is low in the sediments falling within subzone IXa at Katinhännänsuo, but its frequency of occurrence in relation to the total number of grains counted is nevertheless sufficient to suggest that settlement probably continued uninterrupted in the parish of Vihti from the Boat-axe culture onwards. The amount of Cerealia pollen found at Katinhännänsuo is all the more significant in view of the isolated position of the site compared with the other areas studied. The agricultural phase located at 130—220 cm, which is clearly visible even in the AP curves, was previously dated to the Iron Age (VUORELA 1972, Hel-253), but now appears on the basis of the present series of C^{14} dates to extend into part of the Bronze Age as well. The rarity of Bronze Age finds may thus be interpreted as due to a shortage of the raw material, bronze, and the widespread use of wood and bone, a fact which is seen in many places to account for the scarcity of archaeological finds from this particular period (af HÄLLSTRÖM 1948, KIVIKOSKI 1955).

Dates have been obtained for the level in the Kirkkojärvi, Loimansuo and Katinhännänsuo diagrams where the proportions of agricultural indicator pollen, as reflected in the total curve for these species, show a relatively sharp decline. The dates concerned are 2480 ± 120 B.P. at Kirkkojärvi, 1970 ± 100 B.P. at Loimansuo and 1940 ± 110 B.P. at Katinhännänsuo. Bearing in mind the error margins, this feature may be attributed to the climatic deterioration which occurred at the boundary between

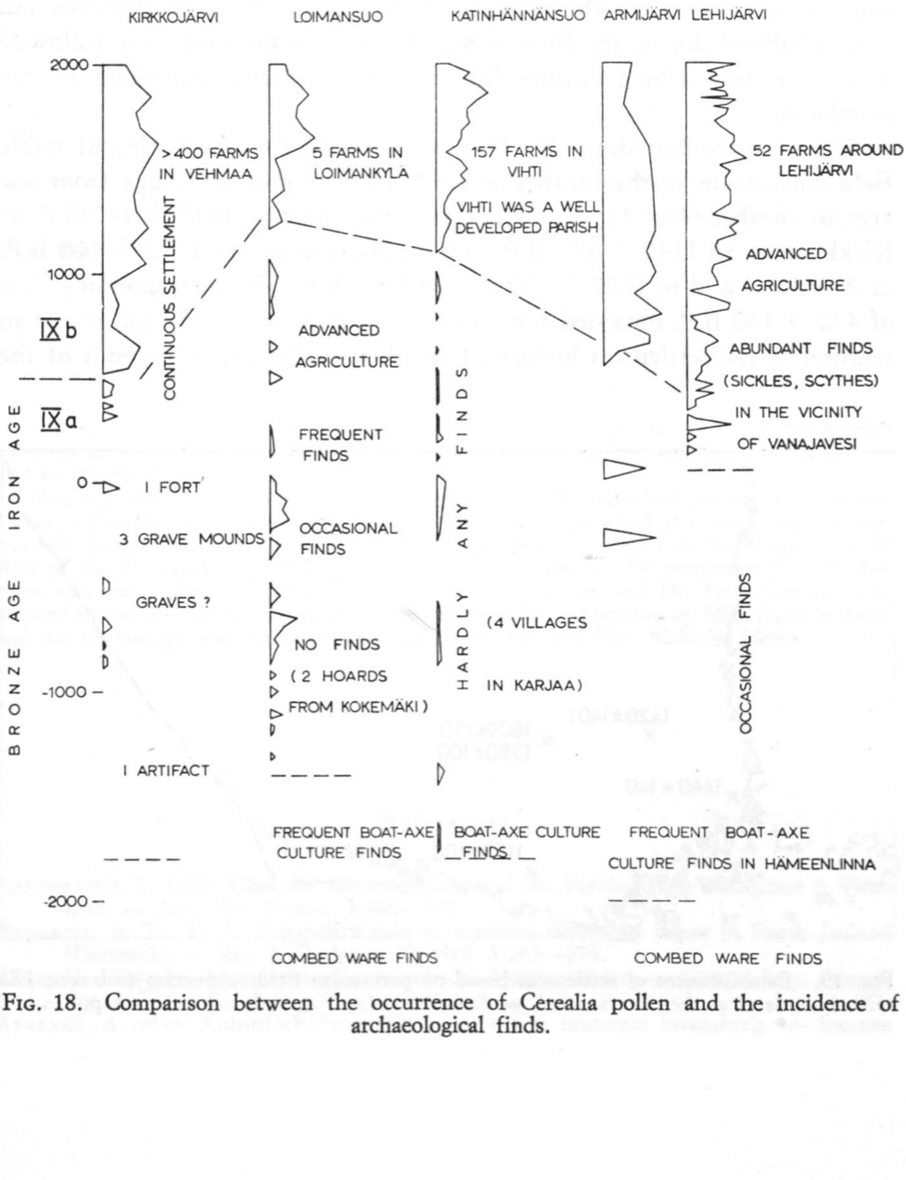


FIG. 18. Comparison between the occurrence of Cerealia pollen and the incidence of archaeological finds.

the Bronze Age and the Iron Age, around 500 B.C., and to the consequent decline in the amount of agricultural activity. This is also observable in many Scandinavian studies (Nilsson 1961, Berglund 1966 and Königsson 1969 a, b). Even so the results obtained here do not suggest the complete abandonment of agriculture or settlement activity in the area.

No evidence of agriculture is found at Armijärvi during the period of the Boat-axe culture, as the earliest occurrences of Cerealia (2270 ± 110 B.P.) date back only to the pre-Roman Iron Age, although an older period of settlement in the surroundings of Armijärvi can be demonstrated from the presence of *Plantago lanceolata* and *Plantago major.* These findings are entirely in agreement with the archaeological evidence, for if this area had been inhabited during the Bronze Age the population must have followed a hunting and fishing culture leaving few artifacts, and those mostly perishable.

The sub-zone boundary IXa/IXb, which reflects the beginning of stable field cultivation in the locality is seen to differ greatly in age from one area to another (Figs 16, 18, 19). It has been dated to 1440 ± 140 B.P. at Kirkkojärvi, to 1140 ± 140 B.P. at Katinhännänsuo, to 1380 ± 100 B.P. at Armijärvi and to 1600 ± 150 B.P. at Lehijärvi. The corresponding date of 420 ± 140 B.P. obtained for Loimansuo has proved to be too recent in relation to the settlement history of the district, largely as a result of the

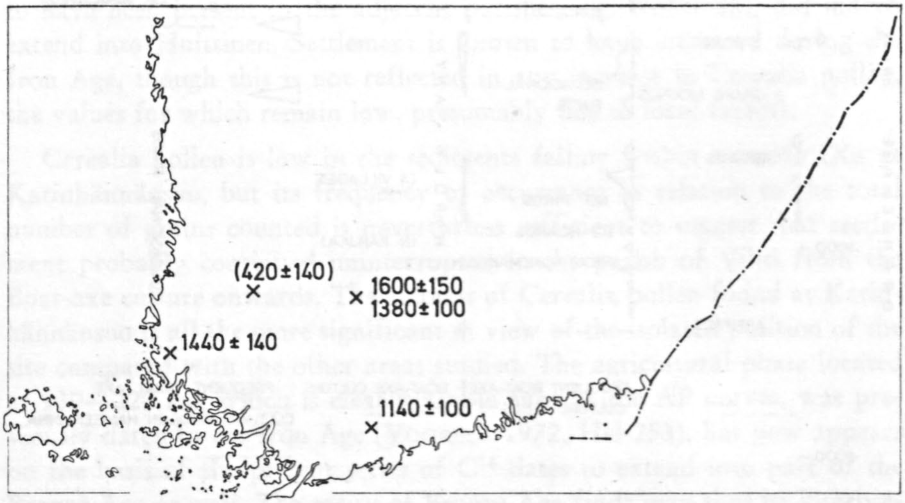


Fig. 19. Establishment of settlement based on permanent field cultivation (sub-zone IXa /IXb boundary) at the sites studied, as determined from agricultural indicator pollen and C^{14} dates B.P.

local conditions of sedimentation, as described above. The dates at the other sites, however, correspond extremely accurately with the historical data available on the settlement and development of the areas concerned. The comparison succeeds especially well in highlighting the recent introduction of field cultivation into Uusimaa by comparison with South-Western Finland and Häme (cf. KAUKOVALTA 1931, KIVIKOSKI 1955, 1961).

The results point to the indisputable value of Cerealia pollen as an indicator of human settlement and the potentialities for its use, together with appropriate radiocarbon dates as research material which may serve to complement the available data on archaeological finds and which may be meaningfully matched with these. Relative pollen values, however, fail to supply any information on the size of the area under cultivation all the time that fluctuations are found in total pollen concentration, especially that of NAP. The tracing of trends in settlement and in the extent of agriculture by palynological methods would require a relatively narrowly-spaced series of radiocarbon dates. At the same time other special demands would be placed on the nature and structure of the profiles which the present material is incapable of meeting.

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